CA’ FOSCARI UNIVERSITY OF VENICE

Department of Economics

Master’s Degree programme – Second Cycle (D.M. 270/2004) - in

Economics and Finance

Final thesis

Risk transfer tools in the Italian financial market: catastrophe bonds

Supervisor:
Prof. Marco Corazza

Co-supervisor:
Prof.ssa Diana Barro

Graduand:
Giovanni Dalle Carbonare

Matr. number:
838224

Academic Year 2016-2017

Index

Figures index

Tables index

Charts index

Introduction

This thesis is an analysis of a particular risk transfer tool known as catastrophe bonds, one of the main financial tools for the securitization of catastrophe insurance risks. Firstly there will be an introduction of financial risk transfer with Credit Default Swaps and Collateralized Debt Obligations, which are two of the most widespread financial hedging instruments, then the focus will move to catastrophe bonds. This topic will in fact be introduced and analysed in the second part of the thesis, while the last part of this work will focus in particular for what concerns catastrophe bonds underlying earthquakes in Italy.

Generally speaking, to avoid financial risk exposure, one party who is facing a risk holding a financial position can move that risk to another party who receives a premium for bearing that risk. The purpose of risk transfer is exactly this: moving the risk from one party to another through a form of insurance.

The first chapter introduces financial risk transfer tools such as Collateralized Debt Obligations (CDOs) and Credit Default Swaps (CDSs). These two financial derivatives were chosen to introduce catastrophe bonds because of their wide spread and heavy use since their development and because, as catastrophe bonds do in occurrence of a catastrophic natural event, CDSs and CDOs provide a sort of protection against negative financial events.

These two financial derivatives act both as a form of insurance, transferring risk from one party to another. In particular CDSs give protection against the risk of default of a bond or of a loan. The holder of a loan or a bond transfers the risk of default of the debtor (thus of insolvency) to a third party, who receives a periodic payment by the holder of the bond. In return, the third party commits himself to pay the nominal value of the security in case of default of the debtor. CDOs instead pool together cash

flow-generating economic assets and issue multiple tranches of different classes of financial claims with different levels of seniority against the collateral pool.
In the first chapter these financial hedging instruments and their behaviour are briefly described.

Insurance companies bear several risks in place of their clients. For this reason the occurrence of a natural catastrophe where their exposure is very high could lead to insolvency by insurance companies. The second chapter introduces and analyses a particular financial instrument of reinsurance developed in the middle ‘90s to face this problem: catastrophe bonds. This particular type of bonds allows insurance companies to transfer at least part of their risk to the capital market and to avoid the risk of becoming insolvent in case of occurrence of a big natural catastrophe.

The structure of cat bonds provides in fact that the insurance company holds the investors' capital in whole or in part if a certain catastrophic event occurs, like a hurricane of a certain scale, an earthquake of a certain magnitude or a total insurance loss exceeding a certain amount. For this risk faced by investors, catastrophe bonds are high-yield securities that pay quite higher premiums than standard corporate bonds, but their maturity is usually less than five years.

The two main figures in the issuance of a cat bond are the insurance company, which is the sponsoring firm, and an SPV (Special Purpose Vehicle), which is a subsidiary company established by the sponsoring firm just for the issuance of the bond.

In the first part of the second chapter the development, the mechanics and the behaviour of this specific instrument are explained and analysed.

The second part studies instead the valuation of catastrophe bonds, analysing how the yields work, the most important variables used for the valuation of the bonds and the methodologies used for the rating of this type of securities.

The third part of the chapter presents the variables to be taken into consideration for the choice of the jurisdiction where to establish the special purpose vehicle needed for the issuance of a catastrophe bond, with particular attention to European countries.

The chapter will finally provide pros and cons considerations about this particular financial instrument.

In 2015 the insurance company UnipolSai issued the first cat bond covering earthquakes in Italy until January 2019, and in August 2016 an earthquake occurred in central Italy.

The third chapter will firstly provide an analysis of UnipolSai portfolio to better understand how an earthquake could affect the catastrophe bond issued by UnipolSai underlying the earthquake, whose name is Azzurro RE I Limited, and the influence that the latter had on this bond.

Secondly, an analysis of Azzurro RE I Ltd. catastrophe bond itself will be provided, in particular of all the features of the coverage of the cat bond and the results of the risk analysis made by the experts through a specific model, which is presented as well in this section. Moreover several modeled scenarios resulting form the modeled risk analysis are provided with an overview of the effects of every scenario on the catastrophe bond, even applying the model to earthquakes occurred in Italian history and the impact there would have been on this catastrophe bond with these earthquakes.

The third part of the chapter studies why the impact on Azzurro RE I Limited catastrophe bond of the earthquakes occurred in central Italy in August 2016 and in the following months was nothing, both from the point of view of the insurance company and the one of the investors.

Finally, future developments of cat bond in Italy are presented, with a reflection of the social value provided by this financial tool to the community.

Chapter 1

This first chapter has the goal of introducing risk transfer with two widely used financial derivatives, such as Credit Default Swaps and Collateralized Debt Obligations, before deepening catastrophe bond in the next chapter.

Financial hedging instruments: CDSs and CDOs

The purpose of risk transfer is to move the credit risk one has with the positions in his portfolio to another party. The risk passes then from a party who does not want to face the risk to another one who is willing to bear that risk for a premium or a fee. Risk can be transferred between individuals, from individuals to insurance companies and from insurers to reinsurers.

The case of risk transferred between individuals gave birth to credit derivatives that portfolio managers use to hedge their positions in the market such as Credit Default Swaps (CDSs) and Collateralized Debt Obligations (CDOs), while the second is the basis of the insurance market. Risk transfer from insurance companies to reinsurance companies comes from the fact that insurers often take on more risk that the capital they have for paying in case of extraordinary claims. They cede then a part of the paying exceeding a certain amount to reinsurers to avoid the risk of default. For this reason a special kind of bonds that will be analysed in the second chapter has been developed to transfer risk from insurance companies to the financial market: catastrophe bonds.

1.1 Birth of CDSs and CDOs

The first CDS was created in 1994 by a team of experts of J.P. Morgan. In 1994, J.P. Morgan was committed to addressing a serious banking problem: an old, large and important customer, the oil company Exxon, required a substantial credit line of $4.8 billion to face the $5 billion threat in punitive damages for the Valdez oil spill[1]. Because of the Basel I accords of 1988, to grant this loan, J.P. Morgan had to maintain a cash reserve of at least 8% of the amount of the entire loan, as risk guarantee assumed with the counterparty to hold against Exxon's default. To solve this issue, the team of specialists, in particular Blythe Masters, had the idea to use an already existing financial instrument, the swap, transferring (selling) to a third party the credit risk assumed with Exxon. The European Bank for Reconstruction and Development (EBRD) took the risk and burden, in case of default of the oil company, to return to J.P. Morgan the credit line offered; in return the investment bank had to correspond an interest to the EBRD for the entire duration of the contract. In this way J.P. Morgan could accord the loan without being against the regulatory capital requirements needed for Basel I.

Drexel Burnham Lambert Inc.[2] issued the first CDO in 1987 for Imperial Savings Association, one of California's largest savings institutions that later closed in 2003. Initially corporate and emerging markets bonds and bank loans usually were the collateral of CDOs, then in 1997 J.P. Morgan

---

[1] Occurred in Alaska, March 24, 1989, the Valdez oil spill is the second largest oil spill in US history, and is also considered one of the most devastating human-caused environmental disasters, with 10.8 million US gallons of oil spilled in the Gulf of Alaska.

[2] Drexel Burnham Lambert Inc. was an important Wall Street firm operating in the investment-banking field; due to its involvement in illegal activities in the junk bond market, it was forced into bankruptcy in February 1990.

developed a financial instrument called BISTRO (Broad Index Securitized Trust Offering), which divided the risk into smaller parts, making it more desirable for common investors without the capital possibilities of the EBRD. This was actually the first synthetic CDO[3]. Later on, Prudential Securities developed "multi-sector" CDOs that diversified the risk for the investor because if there was a decline in one sector and the corresponding loans in the CDO defaulted, other industries in the same "multi-sector" CDO might not be affected.

In paragraphs 1.2 and 1.3 that follow, a brief explanation of how CDSs and CDOs work is presented, in order to provide a clearer view for the subsequent analysis of catastrophe bonds.

1.2 Credit Default Swaps

A credit default swap (CDS) is a form of insurance against default on a loan or a bond. There are two parties to a deal:

- The protection buyer[4];
- The protection seller[5].

In the standard type of deal the buyer of protection pays a periodic premium to the seller of so many basis points per annum applied to the par value of the referenced asset, payment that can also be made in a single up-front defrayal[6]. If, during the life of the swap, a credit event occurs then the

---

[3] Synthetic CDOs will be deepened in chapter *1.3*.

[4] The party trying to transfer credit risk.

[5] The counterparty that will acquire the credit risk.

[6] In a single up-front payment the money is delivered at the time the contract is

seller of protection has to take delivery of the referenced asset and pay a set amount of money to the buyer of protection (normally the par value of the asset).

For instance, consider a 20 years bond issued by ABC company with par value €2.000 and coupon interest amount of €200. Consider also a bond investor X, who fears a possible default of ABC. To hedge this risk X enters into a CDS with Y, paying to Y incomes of €40 each year, which is proportional to the bond annual coupons. In exchange, if ABC defaults, Y pays X the par value and the remaining interest of the bond; otherwise, if ABC does not default, Y makes a profit on the annual €40 payments. In this way, X transfers the risk of ABC default to Y.

Buyers of protection in credit default swaps include commercial banks that wish to reduce their exposure to credit risk on their loan books, and investing institutions seeking to hedge against the risk of default on a bond or a portfolio of bonds. Sellers of protection include banks and insurance companies who earn premium in return for insuring against default.

The periodic premium paid on a credit default swap is related to the credit spread on the referenced asset. The credit spread is the additional return that investors can currently earn on that asset above the return available on assets that are free of default risk. The CDS spread for a particular reference entity can be calculated from default probability estimates[7]. These default probabilities used in the CDS valuation should be risk-neutral probabilities[8], which can be estimated from bond assets or

signed with a single transaction.

[7] Probability of default estimates describes the likelihood of default over a specific time horizon of the reference entity in the contract.

[8] Risk-neutral probabilities are probabilities of future outcomes adjusted for risk.

assets swaps.

For the calculation of CDSs value, there are three steps to follow:

- Calculate the expected payments made on the CDS;
- Calculate the present value of the expected payoff;
- Calculate the present value of expected accrual payments in case of default.

Both in the calculation of credit spread and CDS value, we use the recovery rate, R, which is the ratio of the value of the bond issued by reference entity immediately after default to the face value of the bond.

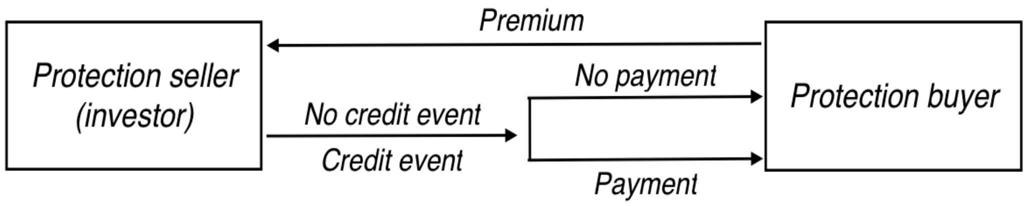

Figure 1: Scheme of the transactions of a CDS.

Below an example of a traditional Credit Default Swap, also known as "*plain vanilla CDS*"[9].

For instance, consider company Y, which pays a premium, the credit default spread, of 90 basis points per year for $100 million of 5-year protection against company X. This spread is paid for the life of the contract or until the default underlying the contract, which in this case is the default

---

For these calculations it assumed the absence of arbitrage opportunities.

[9] The plain vanilla CDS is a traditional CDS that consists in a payment by one party in exchange for a credit default protection payment if a credit default event on the asset underlying the contract occurs.

of company X. If there is a default, the buyer has the right to sell bonds with a face value of $100 million issued by company X for $100 million.

Other than plain vanilla credit default swaps, we can have:

- Forward credit default swap: obligation to buy or sell a CDS on a particular reference entity at a time T;
- Credit default swap option: option to buy or sell a CDS on a reference entity at a particular time T[10], like European style options.
- Binary credit default swap: an instrument that has evolved in the credit default swap market, where the risk characteristics are dependent on the structure of the security itself. This structure poses substantial risk. The investor loses the entire notional amount – not merely coupon and some principal loss – if there is a default event.
- Basket CDS: similar to a single entity default swap except that the underlying is a basket of entities rather than one single entity.

1.3 Collateralized Debt Obligations

A CDO is a financial instrument that pools together cash flow-generating assets and splits this pool of assets into discrete tranches that can be sold to investors. Here, the pooled assets are debt obligations serving as collateral for the CDO.

Collateralized debt obligations change in structure and underlying assets, but the principle to the base is equal: to create a CDO, a corporate

[10] Both options and forwards cease to exist if the reference entity defaults before time T.

entity, known as special purpose vehicle (SPV)[11], is constructed to keep assets as collateral backing packages of cash flows. The portfolio of underlying assets is purchased thanks to the cash obtained with bonds issuance by the SPV.

The CDO is divided into tranches, which catch the principal payments and the cash flow of interest in seniority based sequence. Indeed, CDOs follow a waterfall structure, which guarantees that if one tranche is senior than another, it is more likely to receive promised interest payments and repayments of principal. If some loans default and the CDO collected cash is insufficient to pay all of its investors, those in the lowest, or junior, tranches are the first who suffer losses. The senior tranches, which are the safest, are the last to lose payment from default. Accordingly, coupon payments (and interest rates) vary by tranche with the senior tranches paying the lowest, and the junior tranches paying the highest rates to compensate for higher default risk.

An example of possible tranches of a CDO is provided, in order to clarify this aspect:

- The senior tranche is responsible for payouts exceeding of 20%, earning a spread of 10 basis points per year on the notional principal;
- The mezzanine tranche is responsible for payouts in excess of 5% up to a maximum of 20%, Earning a spread of 100 basis points;
- The equity tranche is responsible for the payouts on the CDSs until they reach 5%, earning a spread of 1000 basis points.

Considering a 1-year timeframe, where the notional principal is $100 million, and the senior, mezzanine and equity tranche principals are respectively: $80, $15 and $5 million, if a company of the CDO portfolio

[11] Special purpose vehicles are deepened in the second chapter.

defaults, it will result in a payout of $2 million. The responsible tranche for this loss would be the equity one (the weakest), which will be left with a $3 million principal, since it was responsible for losses until €5 million. If, lately, during the CDO life there are additional payouts, for example a $4 million one, the equity tranche outstanding principal will turn zero, because it had just €3 million left, so the mezzanine tranche is now required to pay the $1 million left. This means that senior tranches is going to attempt losses only when total payouts will exceed €20 million.

CDOs can be created from a bond portfolio, becoming the so-called *cash CDOs*, which involve a portfolio of cash assets (e.g. loans, corporate bonds, asset-backed securities or mortgage-backed securities). When CDO's tranches are issued, the assets ownership is transferred to the legal entity, the SPV. The risk of loss on the assets is divided among tranches in reverse order of seniority.

On the contrary*, Synthetic CDOs* do not own cash assets like bonds or loans, but they acquire credit exposure to a portfolio of fixed income assets without owning those assets through the use of CDS, the previously explained credit derivatives. Like in cash CDO, the risk of loss on the CDO's portfolio is split into tranches. Firstly, losses will affect the equity tranche, secondly the junior ones, and finally the senior tranche. Each tranche receives a periodic payment, with the junior tranches providing higher premiums. Here, the synthetic CDO originator chooses a portfolio of companies and a determined maturity for the structure. For each company in the portfolio, it sells CDS protection with the CDS maturities equalling the structure maturity. The synthetic CDO principal is the sum of the notional principals underlying the CDSs. The originator has cash inflows equivalent to the CDS spreads and cash outflow when companies in the portfolio default. Tranches are created and they receive the cash inflows and outflows that are distributed.

A very common approach for evaluating synthetic CDOs is the One

Factor Gaussian Copula Model[12], the de facto market model for CDOs pricing, according to which we need to estimate two variables:

- Default probability;
- Default correlation between two assets with same default probability.

Default probability is quite easy to estimate, thanks to ratings[13], fundamental analysis or CDS spreads. Estimating default correlation is much more arduous. Firstly, there are few data on it, secondly because these little available data indicate that default correlation between assets is time-dependent, which means that changes over time. Moreover, at the moment there is not an algorithm for its computation. For these reasons, the Gaussian copula approach uses, as a rough calculation of this default correlation, the correlation between asset prices, which are widely available data. Then, through a series of unwieldy transformations, the model allows the default correlation structure to be estimated.

From an historical perspective we can see how in the early 2000s, CDOs were usually diversified, but by 2006–2007, when the CDO market exceeded the threshold of $100 billion, this changed. CDO collateral became ruled not by loans, though by lower level (BBB or A) tranches retrieved from other Asset-Backed Securities (ABS)[14], whose assets were usually non-prime mortgages. This explains why CDOs are thought to be one of the cause that lead up to the 2007-2009 subprime mortgage crisis, as examined below.

The astonishing development of CDOs is a key factor of boosting

---

[12] The reader can deepen the One Factor Gaussian Copula Model in Anna Schlösser's book "*Pricing and Risk Management of Synthetic CDOs*" (2010), pp. 95-127.

[13] Ratings will be deepened in *chapter 2.3.3*.

[14] Asset-Backed Securities are structured negotiable assets whose performance and reimbursement are covered by the cash flow generated by a "package", or pool, or portfolio, specifically identified with activities with homogeneous characteristics.

prosperity in U.S. as well as triggering the major financial crisis in the history of America; indeed, CDOs have been responsible for $542 billion of the nearly trillion dollars in losses endured by financial institutions since 2007. At the beginning, it seemed that every player was benefiting from CDOs and issuance burst; however, by 2003, different alterations in CDOs were working to create the perfect storm that was released upon financial markets in 2007. First, the collateral composition of CDOs changed as collateral managers looked for ways to gain higher yields. The managers began investing more strongly in structured finance securities, most notably subprime RMBS, as opposed to corporate bonds. As unfolded so far, senior tranches were pooled by mortgage loans with lower default probability and were rated AAA by rating agencies, hence, senior tranches were easy to find buyers in the market. On the other hand, equity tranches were pooled by mortgage loans with low quality and kept by originators or sold to hedge funds, so the only problem left was how to persuade investors to buy mezzanine tranches.

As a result, financial engineers set up mezzanine tranche in a sophisticated structure, pooling ABS CDOs and creating then CDO-Squared. These financial derivatives were exactly like a standard CDO but, instead of being backed by a pool of loans, bonds and other instruments, they were backed by a pool of CDO tranches. This allowed the banks to resell the credit risk they had taken in CDOs.

When the housing market came apart in 2007, so many homeowners started to default on their mortgage payments, as the value of many CDOs was going to zero. Banks lost millions, if not billions.

Investing in CDOs involves different risks and of course diverse yields in relation to these different risks. There is the risk that the underlying portfolio placed as collateral drops into default, at least in part. Then there is the risk of "concentration", that is, if the underlying securities are concentrated in similar industries or in the same sector, then there will be serious losses in case of troubles concerning the whole industry or sector. Another risk is the risk of "structure": investors can decide to buy the best and safest tranches, which have the highest rating (“triple-A”) and lower yield, or the riskier tranches, which have the lowest rating (“junk”) and higher yield.

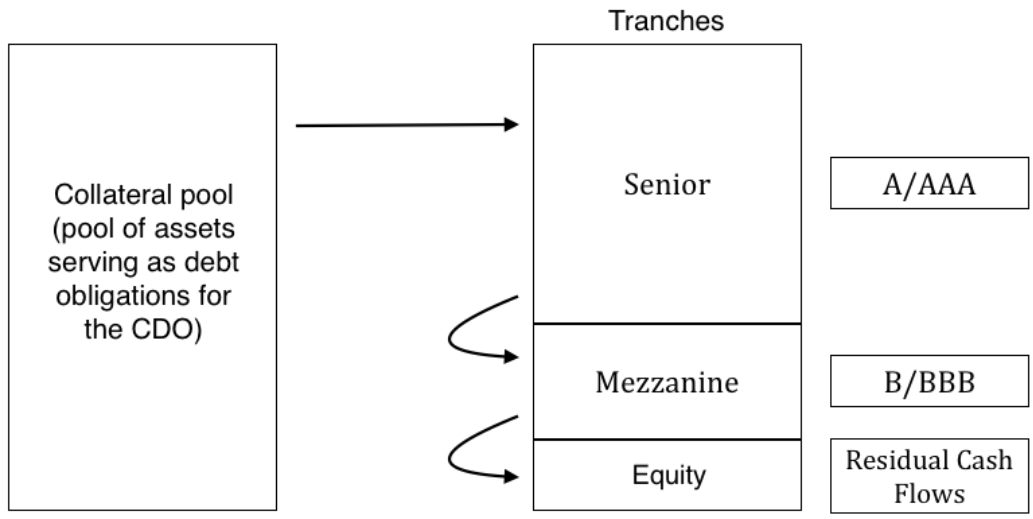

Figure 2: Basic structure of tranches of a CDO.

After this brief explanation of two of the most widely spread financial instruments for risk transfer, CDSs and CDOs, the following chapter will deepen a more recent hedging tool for risk transfer which is used by insurance companies to avoid the risk of default due to catastrophic events, they are called *catastrophe bonds* or *cat bonds*.

These instrument works in a way that, in addiction to the common purpose of risk transfer, is similar to the behaviour of CDSs and CDOs, having another party responsible for losses over a certain amount in a specific event occurrence, as it will be explained later.

This is the reason Credit Default Swaps and Collateralized Debt Obligations the latter have been chosen as opening chapter for this analysis on catastrophe bonds.

Chapter 2

In this chapter, the description of the main features of catastrophe bonds is provided. In particular, their issuance, behaviour, yield, and a consideration of their pros and cons.

Catastrophe bonds

A catastrophe bond, also called cat bond, is a risk transfer operation from the insurer to the capital market. Investors of the capital market accept to take part of the risk in place of the insurance company. In return for a higher yield, and also to acquire a financial instrument whose performance is not related to the financial market since it mainly depends on the occurrence of a natural disaster, an event that is independent of market trends. It is therefore useful even with a view to diversify the portfolio. The higher return is obviously proportional to a risk that cannot be calculated in the classical terms of market performance and the global economy, being a risk related to the happening or not of a natural catastrophe.

They were developed in order to avoid financially unsustainable situations in the event of a natural disaster.

Figure 3 below shows losses in several Countries from different types of natural catastrophes occurred in 2016.

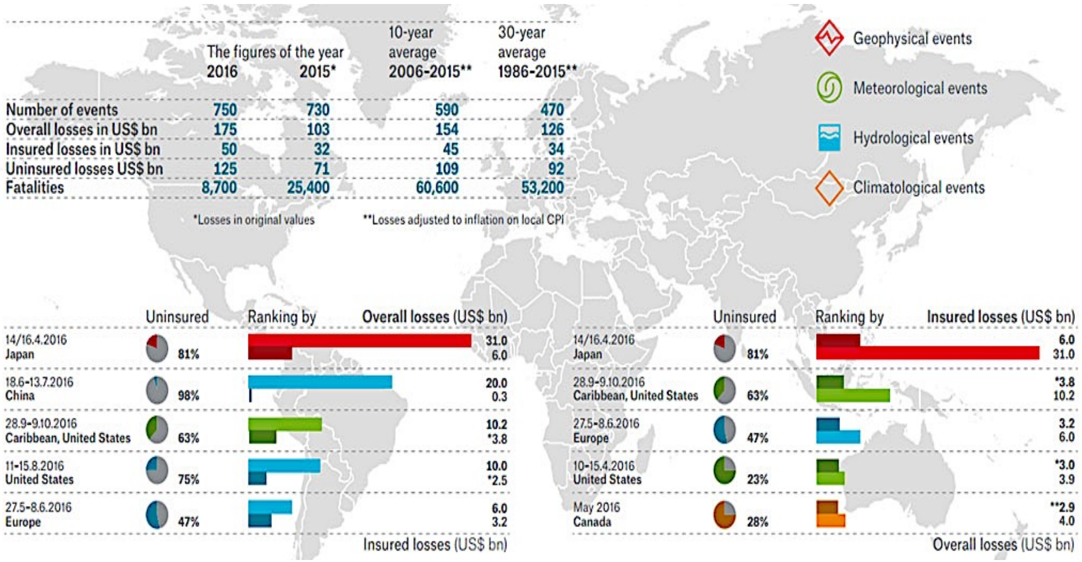

Figure 3: Losses due to most damaging natural disasters in 2016.

The longer and darker bars in the graphs inside the figure above represent the overall losses occurred for a single event expressed in USD billion, while the shorter and lighter ones picture the value of insured losses among the total for that event.

For instance, losses in the United States are shown both for hydrological and meteorological events. In the first case the total loss was $10.0 billion of which just $2.5 billion was insured, thus only the 25% of the overall losses. For what instead concerns meteorological events, for a total loss of $3.9 billion, the 75% was insured, so just $0.9 billion was uninsured.

The case concerning Japan gives even a more clear idea of how important catastrophe bond can be: the overall losses were of $31.0 billion, with just $6.0 billion of them insured, only the 19%.

2.1 Development and behaviour

The need for insurance capital came in the aftermath of hurricane Andrew in Florida in 1992 and the Northridge earthquake in 1994. These events shocked the insurance market: the hurricane caused total losses close to $30 billion, mostly in Florida and Louisiana, while the earthquake is estimated to have caused more than 15 billion dollars worth of damage in the Los Angeles area. In Florida eleven insurance companies were forced into default because of the $15.5 billion total insured losses caused by hurricane Andrew.

These two extraordinary events have prompted the insurance industry to become more aware of the financial impact of major disasters and have highlighted the need for the industry to tap into the markets in order to replenish its assets.

The first catastrophe bond was sold in 1997 by Residential Re[15] to capital markets investors, protecting USA against the risk of a major hurricane. Since then, approximately $45 billion of catastrophe bonds, also called cat bonds, have been issued, providing protection to over 70 insurers, reinsurers, governments, and corporations for a multitude of risks.

Catastrophe bonds are an example of insurance securitization to create risk-linked securities, which transfer a specific set of risks (generally catastrophe and natural disaster risks) from an issuer or sponsor to investors. Insurance securitization can be defined as the transferring of underwriting risks to the capital markets through the creation and issuance of financial securities, whose process involves:

---

[15] Residential Re is a reinsurance company, now specialized in cat bond issuance.

- the transformation of underwriting cash flows into tradable financial securities;
- the transfer of underwriting risks to the capital markets through the trading of those securities.

In this way investors take on the risks of a specified catastrophe or event occurring in return for attractive rates of investment. Should a qualifying catastrophe or event occur (triggers), the investors will lose the principal they invested and the issuer (often insurance or reinsurance companies) will receive that money to cover their losses.

They may be issued by reinsurers, insurers and also insured, with the intention of building a source of financing for losses from harmful events: in fact, the primary feature of these bond issues is that, when malicious events occur within the limits established in the contract, the subscribers will have to support a reduction of their revenue in proportion to the losses.

These bonds can be designed to cover any natural disaster. Some popular issuances cover US hurricanes, European windstorms and Japanese earthquakes. They are often structured as floating-rate [16]bonds and they pay a coupon of LIBOR plus a spread, generally between 2% and 20% and usually their maturity is less than 5 years. Cat bonds are traded in the OTC market; main investors are hedge funds, specialized catastrophe-oriented funds and asset managers.

[16] The coupon rate of a bond can be "*fixed*" or "*floating*", depending respectively on the fact that it changes or not during the duration of the bond itself.

2.1.1 *Catastrophe bond issuance and structure*

These securities may be issued directly by the subject who wishes to transfer the risk, but nevertheless it is much more common that the latter interposes a special purpose vehicle (SPV) between itself and the market.

The very first step is the choice of an independent modelling agent. This is usually a modelling firm that, through the use of catastrophe models, estimates the risk to which the sponsor of the bond is exposed with an accurate risk analysis. It is in the interests of the sponsor to have a precise estimation of the risk, since having a good correlation between the exposure provided by the model and the actual exposure tends to minimize the basis risk[17] of the bond.

After this first step, the structure of catastrophe bonds basically follows other five key steps.

First there is the establishment of a Special Purpose Vehicle in a tax efficient jurisdiction[18] by the sponsoring insurance company.

The SPV is a legally independent company set up for the occasion, which issues securities and personally assumes all obligations arising from the issue: the transferring entity is called sponsoring firm and generally subscribes to the whole capital of the SPV.

The choice of the SPV location is mostly driven by a tax or regulatory

---

[17] In cat bond, the basis risk reflects the possibility that, for a covered event, the security may not be partially or fully triggered, even when the sponsoring firm of the catastrophe bond has experienced a loss.

[18] The choice of the jurisdiction for the establishment of the SPV will be analysed in chapter *2.4*.

treatment comparison and by the initial or recurring cost, so the most used locations are offshore jurisdictions. By the way Ireland, the Netherlands, and Luxembourg are very common onshore jurisdictions for the establishment of SPVs. Secondly there is the establishment by the SPV of a reinsurance agreement with the sponsoring insurance company. Thirdly, a note to market investors is then issued by the SPV and the reinsurance agreement terms are reflected in the default provisions of such note. In order to create money market proceeds to cover eventual losses of the sponsoring firm and to pay part of the coupons due to the investors, the returns generated from the sale of the note are managed in an isolated collateral account as the fourth step. This collateral account is invested in triple A rated securities[19]. In conclusion the principal with the final coupon payment are returned to investors from the SPV if, throughout the entire length of the cat bond, no trigger events occur.

As a first transaction, the SPV issues a bond, under which conditions it is stipulated that the payment of the interest, the return of the capital or both will be inversely linked to the value that will assume in the future a representative size of a given risk. This size is a sector index for a certain geographic area, type of exposure and time period if an index-linked[20] formula is chosen, or the sum of the losses of the sponsoring firm for a certain portfolio of exposures in the case of a firm-specific formula.

The capital raised by the SPV through the issuance of catastrophe bonds are intended available for the financing of a specific risk, and in case of harmful

---

[19] Rating of catastrophe bonds, which is valid for traditional bonds as well, will be described in chapter *2.2.3*.

[20] Index-linked securities and investments in general are investment forms whose performances are linked to the trend of one or more equity indices.

event, amounts that in a normal bond will pay the bondholders, are written off to cover losses: therefore, the bondholders of a cat bond are de facto the insurer's position of the event established in the contract.

Investors buy these securities through investment banks and the bond might be divided in several classes with different conditions about the losses the underwriters have to face, in a way that is similar to the different tranche of Collateralized Debt Obligations.

The SPV concludes then a reinsurance contract with the sponsorship firm, with conditions consistent with the loan so that:

- The duration of the reinsurance contract does not exceed the duration of the loan;
- The hedged risk is the same related to the catastrophe bond conditions, and the losses are generally calculated on the same basis (index or actual losses);
- The amount of coverage coincides with the nominal value of the loan, or is a very high percentage of the loan (80/90%);
- The type of coverage reflects the way subscribers take part in the losses: for example, if subscribers suffer only a fraction of the losses, the reinsurance contract will have the form of the quota share; but if the underwriters suffer all losses above a certain attachment point[21], the reinsurance contract will take the form of a *Catastrophe Excess of Loss* , also said CatXL, with the same attachment point.

[21] It is the point in which investors start to lose the interests of the bond and part of the principal. The attachment point represents the minimum loss.

Quota share treaty is a type of pro-rata[22] reinsurance contract under which the insurer and reinsurer share premiums and losses under a fixed percentage. Quota share reinsurance allows an insurer to maintain a risk and a premium while sharing the remainder with an insurer up to a maximum pre-established coverage. CatXL instead expects the reinsurer to compensate the reinsured for leakage above a certain limit, called *attachment point*, until reaching a maximum roof, said *exit point*. The leak area between the attachment point and the exit point is generally referred to as *layer*: CatXL contracts cover losses from a single event, unlike the stop loss contracts, which cover the reinsured loss aggregate.

Between the reinsurance agreement and the bondholders there is no legal connection, and therefore holders of the catastrophe bonds do not enter into any relationship with the sponsoring firm: this concretely means that in no case the underwriters will be able to retaliate on the sponsoring company in the event of insolvency of the SPV. This is to take off insolvency responsibility from the sponsoring firm.

Finally, the SPV invests the funds raised in liquid financial assets, which perform the function of collateral for the loan, and at the same time for the financing of the sponsoring firm losses.

Through all of the operations described, the SPV's inflow are the capital raised through the bond loan, the reinsurance premiums paid by the sponsoring firm and the collateral yield, while its outflows are due to the interests of the bond loan and the repayment of the loan and compensation to be paid to the sponsoring firm in the event of a claim. The two outflows are then at least in

[22] The reinsurer receives a percentage of premium and pays a proportional share of losses, above the ceding company's retention.

part alternative: if no damage occurs, the SPV owes nothing to the sponsorship and uses the fund to fulfil the bondholders according to the conditions of the contract; if an accident occurs, the bondholders lose all or part of the right to additional payments, and the fund is used for the payment of compensation to the sponsoring firm.

If the premiums paid by the sponsoring company are proportionate with the performance promised to bondholders in the event of no claims, the SPV will be able to fulfil its obligations in any event: in the event of a proper management of the SPV, this eliminates the probability of insolvency.

Even if the occurrence probability of a triggered event is lower, underwriters of catastrophe bonds face a much greater risk than normal bondholders, risk that is offset by a significantly higher interest rate than the average market rate. The rate may be fixed or variable; in this second case, the SPV secures the payment of a spread compared to a market rate such as LIBOR or Treasury bills. The difference between the rate paid to the subscribers and the rate that would have been paid for a similar bond is the premium paid to the underwriters for the risk they have taken.

The figure below shows the basic mechanics of a catastrophe bond transaction.

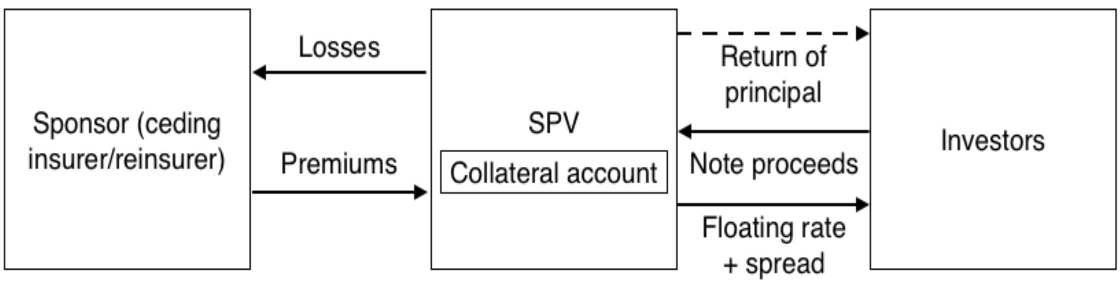

Figure 4: Structure of a catastrophe bond transaction.

The fact that investors lose or not the invested capital in the occurrence of the event underlying the cat bond is then due to the exceeding of specific thresholds set in the contract called "triggers".

2.2 Triggers

The amount of capital and interests that will be received by the investors are affected by a trigger: a trigger is related to the possible losses in a specific area and to their probability. It is usually based on an index. Indexes are established by independent providers. If specified trigger conditions are met, investors may lose all or part of the principal.

They have to be: transparent, objective, quantifiable and durable:

- Transparent means that a trigger must be clear to investors, so that they can easily understand when an event would trigger the cat bond and so when they start losing money.
- Objective means that they must be incontestable: the bond is triggered by an event or it is not; there is no way out.
- Durable means that they must be reliable for all the duration of the catastrophe bond.

There are five major trigger types:

- ‘*Indemnity*’ triggers are based on the actual losses of the insurer and they are widely related with the real possible losses. They act like traditional catastrophe reinsurance. *Attachment point* and *exhaustion* (or *exit) point*[23] of the bond are established. Considering for instance a cat bond with €200 million attachment point, if actual losses from an occurred covered event exceed this value, the bond is triggered.

- '*Modeled loss index*' triggers use software simulations of catastrophe event to compute loss estimates. The software is filled with data regarding the area covered by the catastrophe bond, so for example with the number of insured buildings, the average value of those buildings, insured commercial activities, etc. The model then simulates losses caused from a natural catastrophe in the covered area, simulating the possible conditions that may or may not trigger the bond. This model is designed to eliminate ambiguity in the interpretation of data.
- '*Industry loss index'* triggers: use an industry loss measure published by an independent third party that is known to have the expertise and ability to calculate industry loss within an acceptable degree of accuracy.
- '*Parametric'* and '*Parametric index'* triggers, rather than being based on a claim, are based on observable and recordable meteorological data and physical parameters of an event such as wind speed or earthquake ground motion. Making a very simplified example, consider a theoretical cat bond covering Italian earthquakes, with a parametric trigger of an earthquake occurrence with a minimum Richter scale magnitude of 5.0 recorded by at least three station of the Italian National Seismic Network (Italian: Rete Sismica Nazionale, RSN). If the recorded Richter scale magnitude of an

[23] It is the point at which investors lose all the capital invested, the maximum loss.

earthquake occurred in Italy during the duration of the catastrophe bond is higher than 5.0 for three or more seismological stations among all the Italian National Seismic Network, the bond is triggered. The parametric index is an index composed by several parameters, so it may be less accurate, with the possibility of higher basis risk, but it totally erases the moral hazard. Actually, due to the very tiny differences, 'parametric' and 'parametric index' are often considered as a single type of trigger.

- '*Hybrid*' triggers use combined approaches, for example mixing modeled loss and industry index into one trigger.

In *chart 1* below, it is easy to notice how, among the trigger types mentioned before, in the currently outstanding catastrophe bond and insured-linked securities risk capital, indemnity triggers are by far the most used ones, covering 59.5% of outstanding securities taken into consideration. Industry loss triggers take the second place with 26.0%, which is less than half of the percentage of indemnity triggers. It is easy to notice that parametric and modeled loss triggers are the less used trigger types among the one seen before, covering just 2.7% and 0.9% of the outstanding catastrophe bond and insurance-linked securities respectively.

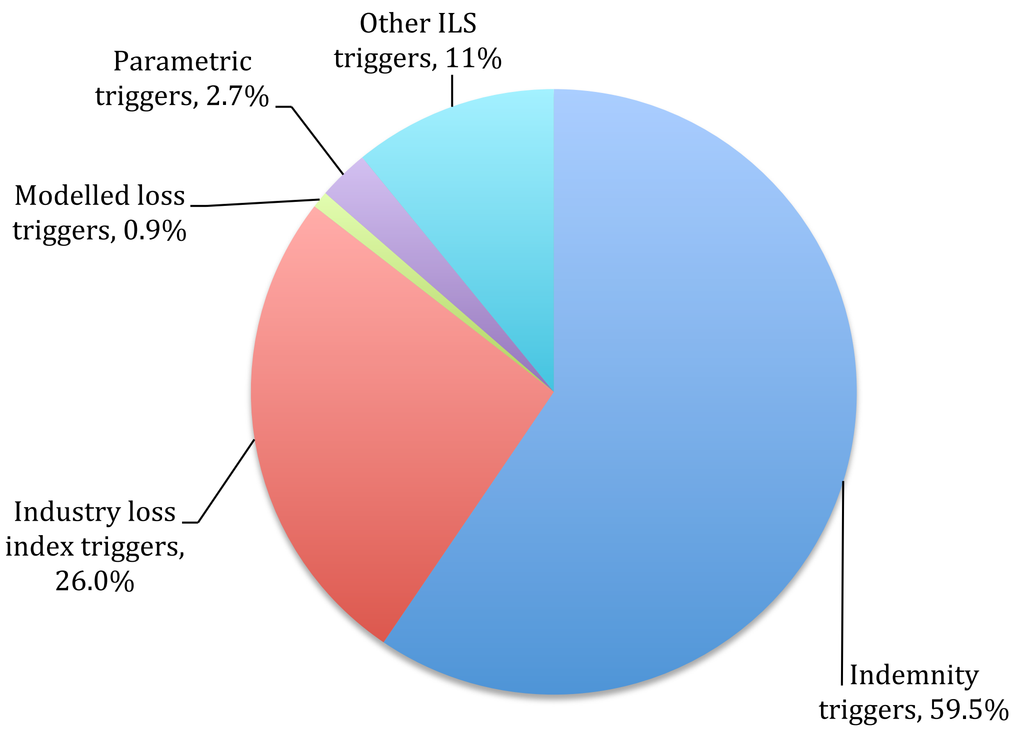

Chart 1: Catastrophe bond & ILS risk capital outstanding by trigger type.

2.2.1 Indemnity trigger

For an indemnity trigger, the triggering event is the actual loss incurred by the sponsoring insurer following the occurrence of a covered catastrophe event, in a given geographic region, for a defined line of business as determined in the contract.

For instance, a bond might be structured to trigger if the sponsoring insurer's residential property losses from a single hurricane in the U.S. state of Florida exceed $20 million, in the time period from April 1, 2015 to March 31,

2018. A bond of this type requires extensive legal definitions of the key terms, such as recognition of loss, the book of business[24] underlying the contract, and what constitutes a hurricane. The underlying book of business could include both commercial insurance as well as personal lines consumer policies.

Indemnity transactions and other risk transfer mechanisms, triggered by direct insurance or reinsurance losses, have a clear benefit to the sponsor of the transaction. Since the sponsor's specific loss experience is used as the trigger, the funds recovered from the catastrophe bond will match the underlying claims very closely, minimizing the sponsor's basis risk (the difference between incurred losses and the bond payout).

However, these risk transfer mechanisms make the underlying risk less transparent to investors, as they cannot access detailed information on every policy or judge the quality of the sponsoring insurance company's underwriting or loss adjusting. Also, indemnity transactions can take a significant amount of time to settle following a catastrophe event, as the insurer must first assess and tally all claims, which can take a significant time. In some cases the bond will extend beyond the scheduled maturity to allow the sponsoring insurer total all claims, especially if an event has occurred near the end of the bond's risk period. This extension period can be detrimental to investors, as their funds are locked up at significantly lower rates than during the risk period.

2.2.2 Modeled Loss trigger

The modeled loss trigger is similar to the indemnity loss one, but with a

[24] In the insurance context, the book of business is a database that lists all of insurance policies the insurance company has written, helping in the making of relevant business decisions.

variation. This time the losses are predetermined through software that simulates various conditions of the specific catastrophe, whether it is an earthquake, a windstorm, a hurricane, etc. It takes into consideration various parameters set such as the number of insured properties, their locations and other variables; then it simulates various magnitudes of the specific natural disaster. When a catastrophic event really takes place, the losses of the actual event are compared to those simulated by the software. Once the losses pass a specific threshold, determined by the software, the bond is triggered.

The cat bond analysed in *chapter 3* is based on an indemnity trigger, but has used the method of modeled loss index trigger for the risk analysis and loss estimations, so it will be studied more deeply in section *3.2.1*, in the specific case of the real bond analysis.

2.2.3 Industry Loss trigger

In the U.S. and Europe, the main accepted providers of insurance industry loss estimates are Property Claims Services (PCS)[25] and PERILS[26], respectively. Both firms undertake to provide estimates of the total loss experienced by the insurance industry after a major catastrophe. Cat bonds based on industry loss operate under the assumption that the sponsoring company's portfolio is aligned with the industry and therefore the sponsor

---

[25] Property Claims Services (PCS) is the leading source of data on insured property losses from catastrophes in the U.S. feature as reporting agency and their data acts as a trigger for many industry-loss transactions.

[26] PERILS is an organisation that provides industry exposure and event loss data and an associated industry loss index service for Australian, European and Turkish natural catastrophes.

recovers a percentage of total industry losses.

Industry loss-based structures are essentially a 'pooled indemnity' solution since the indemnity loss experiences of many companies are used to determine the industry loss estimate. Industry loss triggers are more transparent than pure indemnity transactions as first industry loss estimates from modelling companies are usually available within a couple of weeks after the event. It can, however, take more time for the official loss amount to be released. As for the risk of the bond being extended, it is roughly at the same level as for a pure indemnity bond, and higher than for a parametric trigger.

2.2.4 Parametric trigger

A parametric transaction uses the physical characteristics of a catastrophe event as the trigger. For example, a pure parametric bond might trigger if an earthquake with a magnitude greater than 5.7 occurs within a 100-km radius from L'Aquila. Most parametric transactions are based on an index of the event parameters whereby appropriate weights are applied to measurements from a larger area, which is designed to match the actual losses expected for the sponsoring insurer's business.

Since the parameters of an event are available shortly after an event occurs, parametric transactions are settled much more rapidly than other trigger types and the risk of bond extension is reduced. However, since parametric triggers make no reference to insured loss, there is a likelihood that the sponsor will not receive the precise loss amount experienced from an event. To mitigate this risk, the indices used in the bond trigger are often finely tuned to the sponsoring insurer's exposure. Parametric triggers have proven popular with investors, as the trigger is very transparent; the probability of a region experiencing 160 km/h winds can be easier and more immediate to understand than the probability of a particular insurer incurring $1 billion of losses.

Chart 2 below shows that indemnity triggers are the less transparent for the investors among the five types mentioned, as well as the ones with the lowest basis risk for the sponsor firm.

Parametric triggers instead, whether pure parametric or parametric index, are the more transparent for the investors, with a medium basis risk for the sponsor firm for parametric index triggers and a high basis risk for what concerns pure parametric ones.

Industry loss and modeled loss triggers seem to have similar transparency for investors, which is approximately halfway between the indemnity and parametric index triggers even if industry loss ones are a little less transparent; industry index triggers have also higher basis risk than modeled loss triggers for the issuer.

Hybrid triggers, since they are usually composed as a mixture of industry loss triggers and indemnity triggers, are positioned in the middle between the two, both in terms of basis risk to the cedant and of transparency for investors.

Chart 2 is represents very clearly the trade-off between basis risk to the issuer and transparency for investors for all the types of triggers for catastrophe bonds.

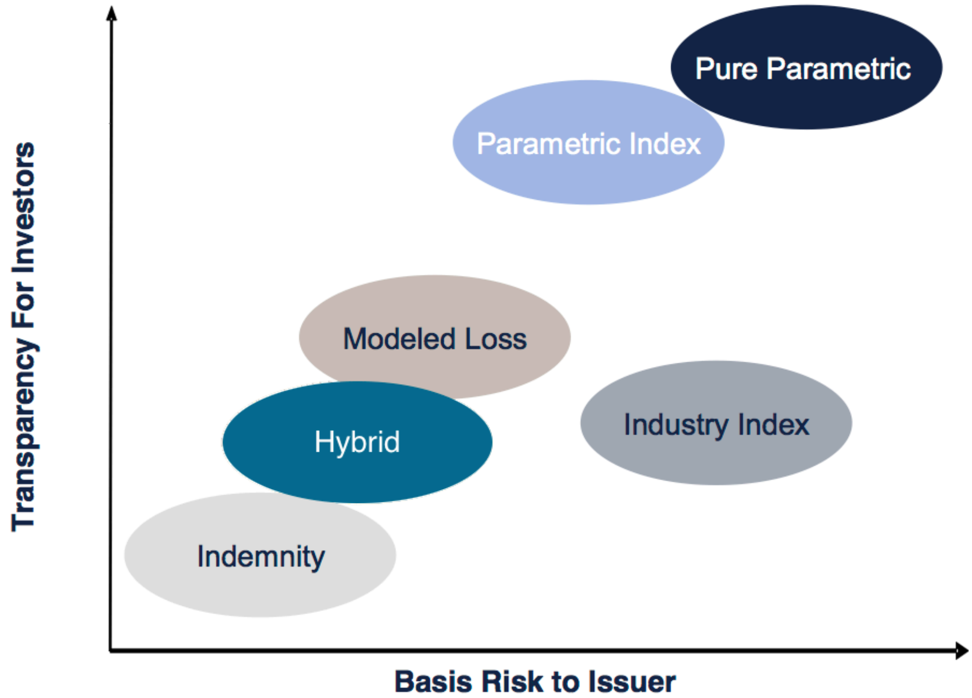

Chart 2: Trade-off between basis risk for the issuer and transparency for the investors for different trigger types.

It is easy to understand that investors are much more willing to invest in bonds with triggers with higher transparency in the top of the chart, so with both parametric index and pure parametric triggers. On the contrary the best triggers for the cedant are the ones with lower basis risk. For these reasons it is important for the issuer, in the trigger design, to minimize the basis risk and at the same time maximize rating agency credit and enhance transparency in order to make the bond more attractive for investors.

Of course lower risk catastrophe bonds will provide lower coupons and vice versa. The yields of these cat bonds are analysed in the next paragraph.

2.3 Valuation of a catastrophe bond

2.3.1 Yields and credit spread

From an investor's perspective, catastrophe bonds are very attractive because of the relatively higher yields they provide.

The yield to maturity of a corporate bond, as the yield of a catastrophe bond, is the total yield an investor acquires from any gains/losses from rise/drop in the price of the bond and all coupon payments while holding the bond to maturity.

The yield can be split into two components: the risk-free interest rate (government bond yield), and credit spread, which is the difference between the total yield of the bond and the risk-free interest rate.

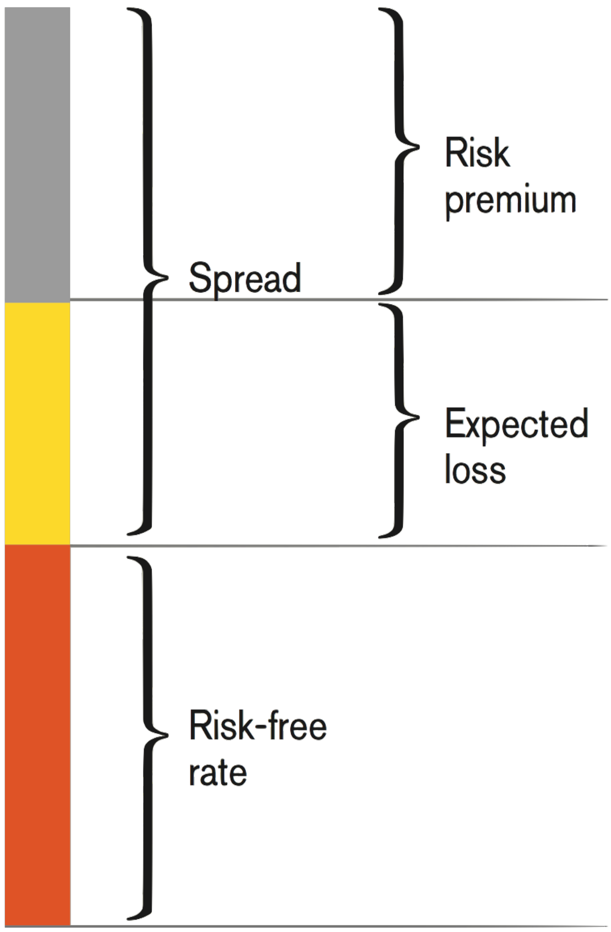

Figure 5: Basic structure of a bond yield.

The credit spread of a corporate bond depends on the default risk (expected loss), so for a cat bond it is the risk of the occurrence of a natural disaster exceeding the trigger, and the risk premium required by investors to take that risk in place of the insurance company. Highly leveraged companies, as well as more probable natural disasters, are riskier, thus they provide higher credit spreads since they imply a higher probability of default/occurrence of disaster. It follows that the higher is the quality of the bond, whether it is a corporate or a catastrophe bond, the lower is the credit spread and vice versa.

More specifically, catastrophe bonds are issued as floating-rate securities, where a set coupon spread over an index or return on high-quality collateral invested by the SPV in short-term money market funds as seen before) is received by investors. The index is not affected by the riskiness of the bond and is destined to repay investors for holding their money.

The return earned over and above the index underlying the bond represents the discount margin of a floating-rate bond. This discount margin is equal to the coupon spread over the index if the bond's price is equal to its face value (or par). Since a bond tends to its face value as it reaches maturity, the discount margin is higher than its coupon spread if the price of the bond is less than par.

As it happens for other risky bonds, the spread of cat bonds is determined by a modeled expected loss[27] and risk premium function. The spread can shift because of a change in perception of expected loss. For example, during a particular seismic activity in central Italy or when a hurricane is approaching Florida, the spread becomes higher due to the increased value of expected loss, since the market notices a higher probability of loss.

[27] Modeled expected loss, also known as loss cost or average annual loss, is the average value of losses over a full range of scenarios, as described in *chapter 3.2.1*.

The supply and demand curve was the thing that most has influenced the pricing of cat bonds in their early market. Ultimately, the initial pricing of a cat bond is determined by the supply and demand curve and the issuance volume; also the weather patterns play a role in catastrophe bond pricing, as the price may for instance rally right before the typhoon season for bonds covering windstorms and hurricanes. Especially in the early days of these securities instead, demand was usually larger than offer and investors were less experienced. Thus, the issuer used to have more power to set the price than today, as investors are now more sophisticated and can rely on much better models that have been developed in the years.

2.3.2 Valuation of catastrophe bonds

Despite the fact that catastrophe bonds have very specific characteristics, the economic valuation methods of these securities do not deviate from those used for traditional bonds. The risk that the underwriters have to suffer losses due to claims may in fact be compared to the default risk of the debtor in a normal bond. Thus, the pure risk transferred from the sponsoring firm to investors in a cat bond resembles the risk that the insolvent issuer is unable to repay the principal or pay interest to underwriters in a standard bond. The points to be analysed for the valuation are then three: which is the probability of suffering a loss, in case of loss how would it be in average, and which is the probability of losing all the capital.

The probability distribution of the loss function is expressed by the Exceedance Probability curve (EP curve), which represents the probability that different levels of loss are overcome as shown below in *figure 6*. The EP curve is the basis used by insurers to estimate their odds of suffering different levels of loss.

To generate such a curve, a collection of simulated events with their expected losses has to be done, grouping them year by year, in order to obtain the loss-causing events for each year. Summing up the mean losses of every event, the total mean loss for each year is obtained. Looking at *figure 6*, in the plot losses are sorted in descending order on the y-axis, while on the x-axis the exceedance probability is shown.

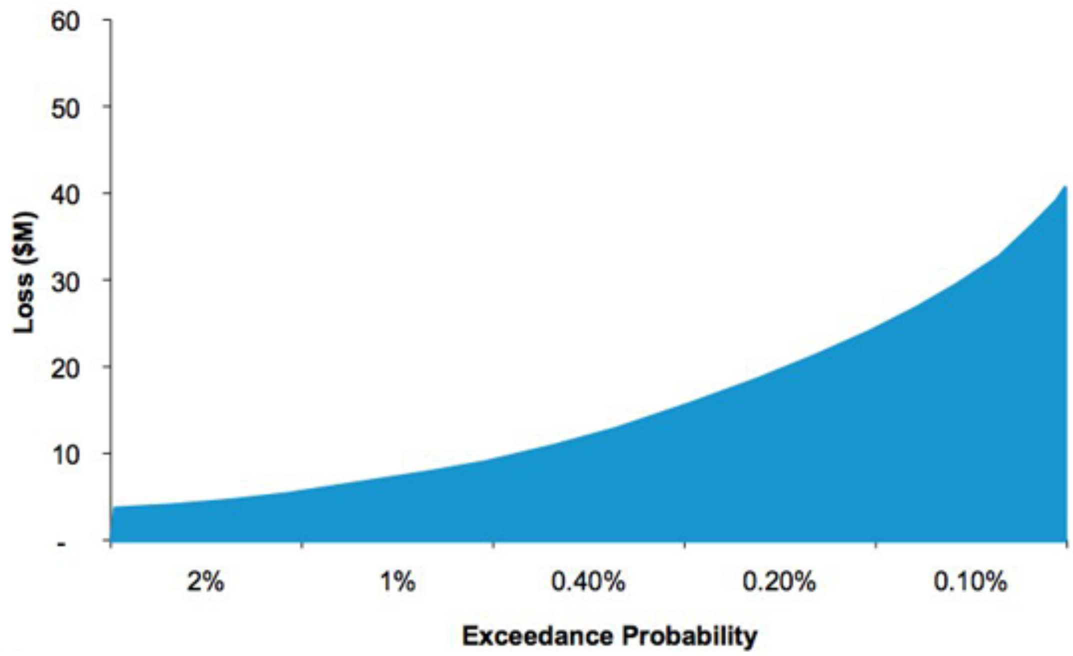

Figure 6: Graph showing Exceedance Probability curve.

The EP curve is the basis upon which insurers estimate their likelihood of experiencing various levels of loss.

Figure 7 represents the EP curve from a different point of view, in order to point out other features such as the expected loss described subsequently (Exceedance probability is on the y-axis and aggregate losses on the x-axis).

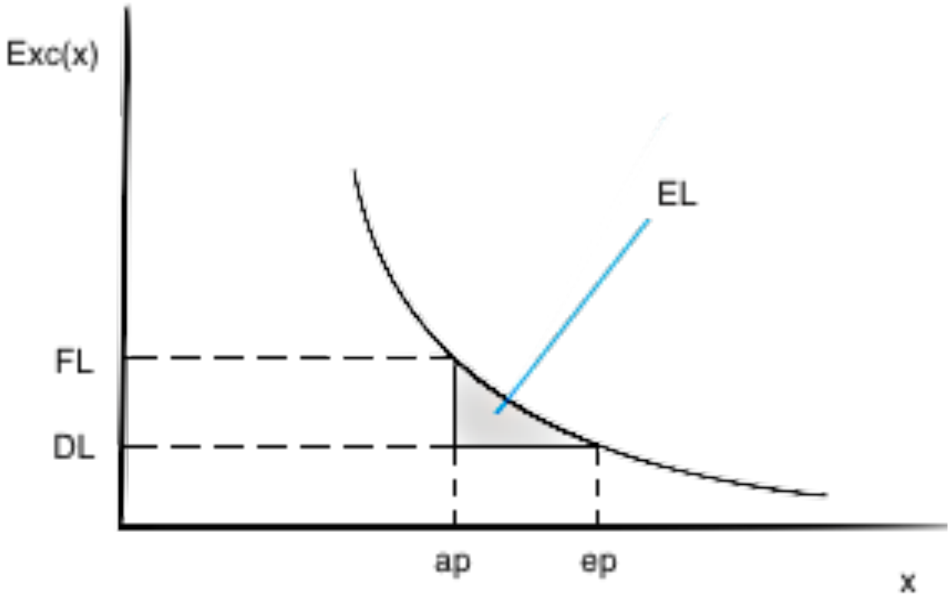

Figure 7: Exceedance probability curve of a cat bond.

Where:

x = aggregate losses;

Exc(x) = probability that losses exceed x;

ap = attachment point;

ep = exit point;

FL = frequency of loss;

DL = depletion loss;

EL = expected loss.

As said before, the *attachment point* represents the point in which the investors start to lose the interests of the bond and a part of the principal.

The *exit point* instead represents the maximum loss considered for the investors, so if reached or exceeded, then the investors lose the entire principal and also the interests, but in no case losses can be higher than the nominal value and interests of the securities.

The *frequency of loss* (FL) is the probability that the aggregate losses of the portfolio referred to the catastrophe bond exceed the attachment point.

The *depletion loss* (DL) is the probability that aggregate losses of the portfolio equal or exceed the exit point; it is the probability to lose all the investment.

The *expected loss* (EL) represents the average losses of the portfolio computed in the range between the attachment point and the exit point. It is the most important of the three measures: it expresses the average loss associated to the investment.

The expected loss is given by the formula below:

$$EL = \int_{ap}^{ep} Exc(x)dx - DL(ep - ap)$$

The expected loss measures the average loss associated with the investment and can be compared to the premium paid by the issuer for the transfer of catastrophic risk that, as seen in the previous paragraph and in *figure 4*, is given by the spread between the interest rate paid by the cat bond and the risk free rate. The expected loss is computed as present value of the possible losses for all the duration of the bond.

Chart 3 below from Artemis, shows the trends of the average expected loss (blue line) and the average coupon (black line) of all catastrophe bonds and Insurance-Linked Securities issuances every year from 1997 until today.

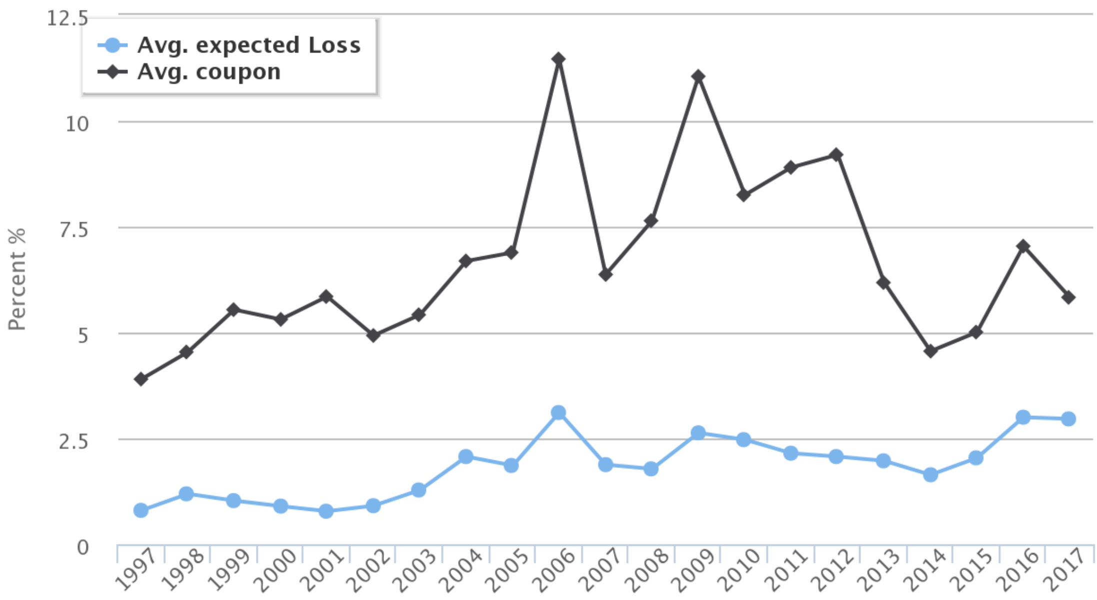

Chart 3: average expected loss and coupon of cat bonds and ILS issuance by year.

At a first sight it easy to notice that the average expected loss is much more stable than the average coupon. In particular there was a big peak of the average coupon of the securities issued in 2006, which jumped from 6.89% of 2005 to 11.46% of 2006, going back to 6.37% in 2007. This was probably due to the several and heavy catastrophes occurred during the two previous years, such as the Indian Ocean earthquake and tsunami of December 2004, hurricane Katrina in the United States and Kashmir earthquake in Pakistan in 2005. The same seemed to have happened in 2009, with a peak of the average coupon from 7.64% in 2008 to 11.05% in 2009 and down again to 8.25% in 2010, maybe because of one of the most devastating floods in Mexican history and the occurrence of a disastrous cyclone in Bangladesh, both in 2007.

Expected loss can be used to obtain the *Expected Excess of Return* (*Eer*). The *Eer* can be considered a measure of the expected return for the subscribers of catastrophe bonds, or rather the differential performance of these bonds compared to the return of risk-free securities. It can be computed as follows:

$$Expected\ Excess\ of\ Return\ (Eer) = Spread - Expected\ Loss$$

From an investor point of view, however, the Eer has the disadvantage of not taking into account the frequency of loss and the depletion loss: sometimes this is considered irrelevant, since some rating agencies use the expected loss as the only measure of the default risk of the securities, whether they are catastrophe bonds or traditional bonds.

2.3.3 Rating of catastrophe bonds

As any other kind of bonds, also catastrophe bonds are given a rating, which is an index that immediately indicates to potential investors how reliable a bond is. Obviously the higher the rating the more reliable is the bond, while the lower the rating, the higher are the probabilities of default of the bond. For this reason bonds with high ratings pay lower interest because of their safer behaviour while low rated bonds pay higher yields since investors face a higher risk of default.

The rating of a bond is given by a rating agency, whose role is to carefully check all the details of the risk analysis of the catastrophe bond provided by the modelling firm, but, if necessary, the rating agency can estimate ex novo the risk exposure of the bond.

The assignment of the rating from a rating agency has five key steps:

1) Evaluate the reliability of the modeling firm: this examination consists not only in the audit of the reliability of the firm itself, but also of its staff. It checks the quality of the information used to build the model and the result of the models built by that firm in the past.
2) Analysis of the model: in this phase the rating agency checks all

the assumptions underlying the model, and can convene the modeling firm to justify its choices or to provide more data, especially in case of hypothesis set to build the model not supported by scientific data or historic facts. The agency has also to consider the duration of the bond to evaluate the reliability of the model: in case of pluriannual cat bonds in fact, a variation of the exposure level or of the reference portfolio could affect the expected loss or other risk measures used to build the exceedance curve. Because of the difficulty of doing a reliable forecast of the growth rate of an insurance portfolio with an horizon longer than two years, usually rating agencies set the attachment point variable over time in the model, in order to be able to modify the growth of the portfolio as needed as they see its real development, and to keep the expected loss (or the other risk measures) constant. Always looking at pluriannual catastrophe bonds, another point to consider is the value over time of the possible losses: since the expected loss is computed as present value of the possible losses for all the duration of the bond, there is an inverse proportionality between the weight of the loss and its closeness to maturity when the loss occurs; so the more the loss is close to maturity, the less weight it has in the computation of the expected loss.

3) New computation of the exceedance curve: if needed the exceedance curve is calculated again with more prudent hypothesis than the ones used by the modeling firm. Usually estimations are done with very high values of the confidence level, like 99%.

4) Review of the legal profile and of the documentation: several checks are done over the SPV; it has to be completely detached

from the sponsoring firm financial affairs and that it complies with all the conditions so that it can reinsure the sponsoring firm, respecting all the planned tax and insurance regulations.

5) Rating assignment: historical average performances of bonds with same duration of the bond to be rated are chosen as benchmark and are classified on the basis of the rating received. Comparing then the results of the model with the results of the benchmarks, the rating given to the bond will be the same of the rating of the benchmarks that performed in the most similar way.

Several rating agencies have a sixth step where the analysts propose the rating to a committee that reviews the rating before the publication of the official rating.

Table 1 below show the ratings scale of the three most important international rating agencies, which are Moody’s, Standard & Poor’s and Fitch Ratings.

	Moody's	S&P	Fitch	Meaning
Investment Grade	Aaa	AAA	AAA	Prime
	Aa1	AA+	AA+	High Grade
	Aa2	AA	AA	
	Aa3	AA-	AA-	
	A1	A+	A+	Upper Medium Grade
	A2	A	A	
	A3	A-	A-	
	Baa1	BBB+	BBB+	Lower Medium Grade
	Baa2	BBB	BBB	
	Baa3	BBB-	BBB-	

Junk	Ba1	BB+	BB+	Non Investment Grade Speculative
	Ba2	BB	BB	
	Ba3	BB-	BB-	
	B1	B+	B+	Highly Speculative
	B2	B	B	
	B3	B-	B-	
	Caa1	CCC+	CCC+	Substantial Risk
	Caa2	CCC	CCC	Extremely Speculative
	Caa3	CCC-	CCC-	In Default with Little Prospect for Recovery
	Ca	CC	CC+	
		C	CC	In Default
			CC-	
	D	D	DDD	

Table 1: Ratings scales from the three most important rating agencies.

As noticeable ratings go from A to D with several intermediate levels between the two and with different notations between the rating agencies (S&P and Fitch have almost the same notation, while Moody's has a little different one).

Ratings are composed from one to three characters. For S&B and Fitch the letters of the ratings are all capital letters and they are not mixed, all the characters must be of the same letter (e.g. AAA, BB, etc.), and can have a "+" or a "-". Moody's instead uses also different letters in the same rating and only the first is a capital letter, followed by zero to two lower case "a"s (e.g. Aaa, Ba, Caa, D) and can have a number from 1 to 3.

For all the three agencies the best rating is triple A and the worst is D for Moody's and S&P and triple D for Fitch. In general, for each – let us call –"letter class" of ratings (class A, B, C and D), ratings with three letters are the best of the class, then those with two letters come and finally those with one. Among ratings of the same letter class with the same number of letters, Fitch and S&P

indicate with a "+" higher ratings, and with a "-" lower ones, leaving the middle rating with just the letters themselves (BB+, BB, BB-). Moody's in its place indicates with 1, 2 and 3 respectively better, middle and lower ratings of the same letter class (Ba1, Ba2, Ba3).

2.4 Choice of the SPV jurisdiction

As said in paragraph *2.1.1*, SPVs are very often established on offshore jurisdictions because they provide better conditions. Nevertheless there are three nations in Europe that have onshore jurisdictions that make these countries suitable for the establishment of SPVs for catastrophe bonds: they are Ireland, Luxembourg and the Netherlands.

Besides the importance of the choice of an independent country with political stability, this section will outline some of the key aspects in the choice of the jurisdiction for the establishment of a Special Purpose Vehicle comparing these aspects for all the three countries mentioned above.

2.4.1 Minimum capitalization and time of establishment

The first issues to consider for choosing the jurisdiction are the time needed to establish the SPV and the minimum capital requirement needed to be able to establish it.

Ireland

The choice for an Irish SPV may lead to the establishment of one between two types of companies: Ltd. companies[28] or PLCs[29]. The differences between the two are both in terms of time of establishment and in terms of needed capital.

Ltd. companies need five business days to set up, with no minimum capitalization (just €1 is enough) and the incorporation costs (which are set up fees, registration and similar costs) of such a type of Irish company are around €2,000.

The establishment of a PLC is necessary in case of transactions that involve large-scale retail offers with low denomination securities[30]. Even if, as Ltd. companies, it can take five business days to be incorporated, PLCs may need up to fifteen business days to achieve full operational regime. The minimum capital requirement for this type of companies is €38,100 and, even if it is fully capitalised almost always at the outset, by law just the 25% would be needed to be paid up immediately. Incorporation costs of PLC companies are approximately €3,000.

Luxembourg

Also in Luxembourg an SPV can be of two types of companies: Sarl (Société à responsabilité limitée) or SA (Société anonyme), which are respectively the Luxembourgian equivalent to the Irish Ltd. companies and PLCs seen before.

Both Sarl and SA companies need five business days to be set up.

---

[28] Ltd. is a suffix that indicates a private limited company, where members' liability is limited to the capital invested.

[29] PLC stays for public limited company, which designs a company that has limited liability and has offered shares to the general public.

[30] Retail bonds are low denomination securities aimed at private investors.

The minimum capital required for the establishment of a Sarl is €12,500 and it must be fully capitalised at the outset.

As for Irish PLCs, also for SAs it is standard practice to fully capitalise the minimum capital requirement that in this case is €31,000, of which just 25% would have to be paid at the outset by law.

Both Sarls and SAs face incorporation costs of approximately €2,500 and around other €5,000 for further set up fees.

Netherlands

Even a Dutch SPV needs up to five business days of time of establishment and usually takes the form of a BV (Besloten Vennootschap), which is the Dutch version of a private limited liability company. This type of company requires a minimum of 1 Director, whether it is a body corporate or a natural person. Very often the shares of SPVs in the form of BVs are held by a '*stichting*' [31].

Until October 2012, the minimum capital required was €18,000, but then the Dutch Parliament has abolished the requirement of a mandatory minimum capital for BVs, allowing this companies to have a share capital of €0.01. Incorporation costs are approximately €6,500.

2.4.2 Corporate administration costs

After considering the establishment cost, it is time to take into consideration the administration costs of an SPV in each of the three Countries.

---

[31] A stichting is a Dutch legal entity born from the donation of an estate of a person or of a company to realize a specific purpose. As for the case of Dutch SPVs it may own property or assets, but it can also open bank accounts, have obligations or debts.

Ireland

Irish SPVs, as well as SPVs in Luxembourg and in the Netherlands, have to face several fees and administration costs. Set up fees are around €3,000 and the one due to the corporate service provider (CSP) is approximately €16,000 per year, and it is important that the services to be provided by the CSP are exactly determined when assessing fee quotations, in order to know precisely what the CPS will provide and what not. Moreover there is a minimum of two personal directors, whose fees are €5,000 each per year. There is the need of a Share Trustee[32] and of secretarial services, which in Ireland are separate services and both may or may not be provided by the corporate service provider package.

Considering all these costs, in the first year the total owed to the Irish CSP is around €35,000, going down to €30,000 per year for the following years.

Luxembourg

Luxembourgian set up fees are around €5,000, while costs for the corporate service provider are around €20,000. This leads to first year's costs owed to the CSP approximately between €25,000 and €30,000 and subsequently between €20,000 and €25,000 per year.

Netherlands

Dutch corporate administration costs are very similar to the ones seen for Luxembourg: €5,000 of set up fees and €20,000 of annual management to the corporate service provider, so between €20,000 to €25,000 per year.

---

[32] The Share Trustee retains the beneficial ownership of all the shares, subject of course to the declaration of trust that the Share Trustee itself will make.

2.4.3 *Auditing requirements*

Since companies in each of these jurisdictions are required to undergo an audit once a year, these costs must be taken into consideration.

Ireland

An SPV established in Ireland is due to file annual audited accounts, in accordance with IFRS or GAAP[33] in Ireland. Auditor's fees are almost the same owed to the CSP since they are between €15,000 and €17,000 per year.

Luxembourg

Luxembourg securitisation law of 2004 defines that the accounts of a Luxembourgian special purpose vehicle must be audited by an external '*reviseur d'entreprise'*, which means 'company auditor'. The costs of this figure are around €15,000 per year.

Netherlands

Every year Dutch BVs must prepare annual financial statements certified by a licensed auditor and then submitted to the Netherlands Tax Authorities. Also in the Netherlands the auditor's fees are around €15,000.

---

[33] IFRS and GAAP stay respectively for 'International Financial Reporting Standards' and 'Generally Accepted Accounting Principles'. The first are a set of international accounting standards that state how particular types of transactions and other events should be reported in financial statements, the second are a common set of accounting principles, standards and procedures that companies must follow when they compile their financial statements.

2.4.4 *Issuer's taxation, minimum retained profit and withholding tax*

Ireland

The tax rate for Irish companies depends on the nature of the business of the companies. The lowest possible is 12.5%, making Ireland a very convenient place to establish a company from this point of view, but for an Irish SPV the tax rate raises up to 25% for the nature of its profits.

For what concerns interests paid by an Irish SPV on loan facilities or on notes, there is a 20% withholding on those paid interests, unless an exemption applies.[34]

If an Irish SPV makes payments using interest rate swaps[35], those payments are usually not subject to Irish withholding tax.

Luxembourg

From a 2004 law, a Luxembourgian SPV has the same taxation of a fully taxable company. Despite this, all payments to any creditors and to holders of shares or securities are tax deductible. It is immediately clear that a Luxemburg SPV can easily avoid complying with this law, obtaining profits with no taxation, since they just need to do not exceed earnings that are just as high as the amounts they have to pay to those figures with tax-deductible payments just mentioned.

---

[34] An exemption that often applies is when interests are paid to a person resident in a jurisdiction with double tax treaty with Ireland or in a nation member of the EU (different from Ireland).

[35] Interest rate swaps are financial derivatives contracts between two parties to exchange future interest payments based on a predetermined principal.

Moreover, distributions to investors are neither subject to withholding tax nor to municipal business tax.

Netherlands

SPVs in the Netherlands usually have a nil tax rate. This is possible because they are structured so that the minimum profit they reach adds no costs to the deal as simply explained below. The income tax rate of the first bracket of profit for a Dutch corporation is 20%. So, assuming CSP costs of approximately €15.000 and a total income of more or less €20.000 as it usually happens, the after tax profits (which amount to €16.000 with the taxation already mentioned) are used to pay the corporate service provider as tax exempt dividends, adding no costs at all.

Moreover there are no laws providing withholding tax on interest paid on securities issued by an SPV in the Netherlands.

For the catastrophe bond that will be analysed in the following chapter, which is the first covering earthquakes in Italy, the establishment of an Irish SPV was chosen.

2.5 Pros and cons of catastrophe bonds

Every financial instrument has its points of strength and of weakness, and so do catastrophe bonds.

Of course, as they were intended for this purpose since the beginning, cat bonds are very useful for insurers or reinsurers, who are the typical issuers of catastrophe bonds, as they offer a way to cover the risk of rare but severe entity natural events, moving the risk to the capital markets. Doing this, the capital of the insurance or reinsurance company, and so the share capital, which it is supported by, is safe from the eventual losses caused by the event underlying the bond.

From the point of view of the investor, this tool is an instrument to invest in the insurance environment, without facing the risk of buying shares, which face all the risk taken by the company. Catastrophe bonds allow investors to choose a specific insurance risk, diversifying their portfolio with securities uncorrelated to financial market behaviour.

Insurance and reinsurance companies, in their standard business, take the risks of others that, among the whole book of business of the company (see chapter 2.1.1.1), can be compensated. Investors in catastrophe bonds instead, take the risk because, among all their portfolio of financial activities, gains and losses can be compensated as well. Thus, insurance and reinsurance companies and the buyers of cat bonds have a similar goal in their financial behaviour.

From the investors' point of view, one of the main advantages of cat bonds is the fact that its performance is almost completely uncorrelated to the trend of the market and of standard financial or non-financial activities. This means that in theory the payments and the behaviour of an existing catastrophe bond should not change in case of a financial crisis or scandal such as a bank default, as shown in *figure 8 below*. Here it is easy to notice that when in 2008 the returns on standard indexes (like benchmarks such as the S&P 500 Index and the S&P Listed Private Equity Total Return Index) collapsed with the Lehman Brothers default[36], the returns on catastrophe bonds indexes (like Swiss Re Cat Bond Total Return Index represented in the figure) experienced

[36] Lehman Brothers was the fourth-largest investment bank in the US, whose 2008 bankruptcy is the largest in American history.

instead only a little drop with major catastrophes like 2011 earthquake in Japan, soon recovered and resulting just as a blip in un upward trend.

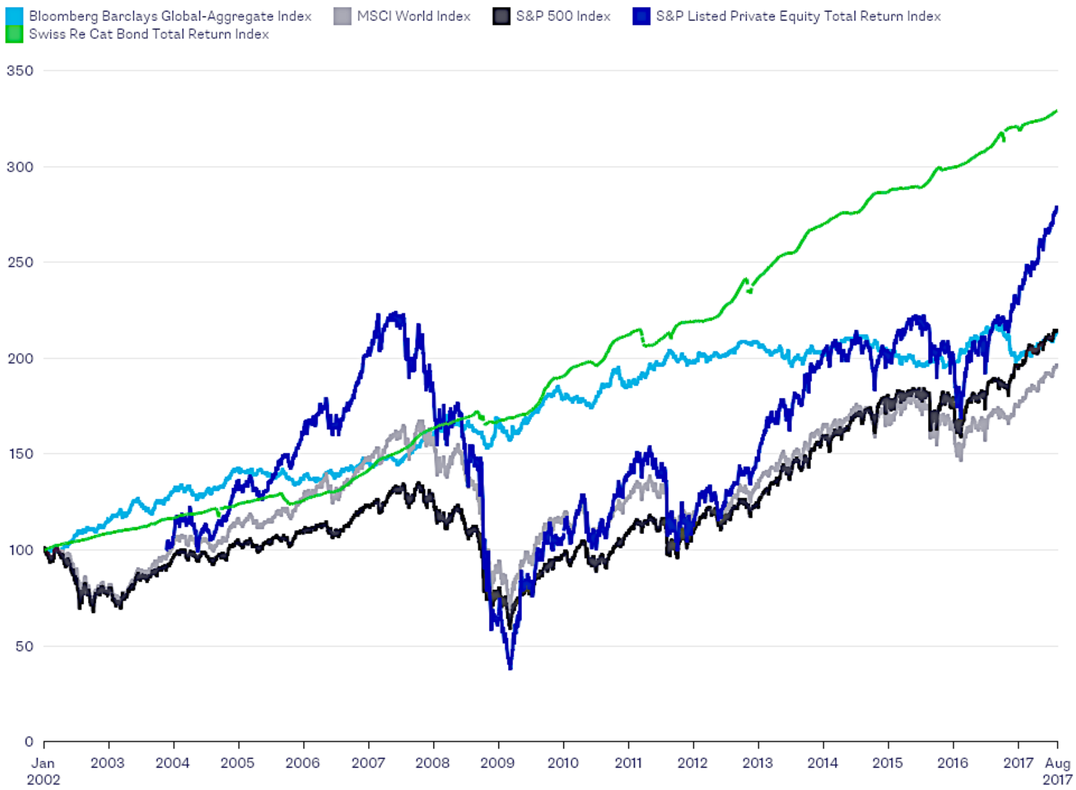

Figure 8: Swiss Re Cat Bond index compared to benchmarks.

(Source: Bloomberg).

Moreover, the yields of the cat bonds are always considerably higher than the ones of standard securities.

Again, the sponsor of the catastrophe bond can take advantage of two more things when comparing this tool to a standard reinsurance contract. First, the credit risk is cancelled in the moment the SPV has raised the capital through the issuance of the cat bond. This capital in fact is the money that would be used in case of losses, avoiding then for the sponsoring firm the credit risk of an insolvent reinsurer with a standard reinsurance contract.

Secondly, catastrophe bonds are an almost completely mouldable and flexible instrument: the sponsoring company can set the type of event underlying the contract, the attachment and exhaustion point, the duration of the contract and the capital to be raised. For example, with a catastrophe bond, the relationship between an investor and the sponsoring firm has an end with the end of the bond, while a reinsurance contract usually has reinstatement clauses to be signed.

This flexibility, compared to the one of usual reinsurance contracts, is something unknown since the latter are mostly predetermined and structured policies.

Among all the disadvantages, one big con of catastrophe bonds is the fact that one could lose everything invested in just one night, which is quite a significant con.

Investing in cat bond is in fact considered by some people as gambling with the weather, which can be actually considered partly true. Before investing in such a tool, a deep study of the terms of the bond and a research on the area involved in it have to be made, but in the end it all comes down to natural events, which are almost unpredictable.

By the way the risk of losing all the money invested is always very low.

Consider for instance the very recent hurricane Harvey in Texas, which has flooded Houston and caused damages estimated to be between $50 billion and $70 billion. The CFO of Aon Securities[37], Paul Schultz, explained in an

[37] "Aon Securities is a global investment bank with expertise in mergers and acquisitions, capital raising, strategic advice, restructuring, recapitalization services, and insurance–linked securities. Aon Securities works with insurers, reinsurers, investment firms, banks, and corporations to manage complex commercial issues through the provision of corporate finance advisory services, capital markets solutions, and innovative risk management products." (www.aon.com).

interview with Bloomberg TV, why this major hurricane is not likely to hit cat bonds underlying the area: this because the latter were far more focused on damages caused by wind rather than by flooding, and of the billion of damages caused by this hurricane, most of them were caused by the flooding, so not triggering the bonds.

Another risk is the risk of the occurrence of a triggering event that would use the totality of the available risk cover at the beginning of the bond or reasonably far from maturity. In case of another big triggering event, the risk could not be covered. This is also the reason why the duration of catastrophe bonds is never higher than 3-5 years.

The next chapter will deepen the case of a 3.5-year cat bond, which is the only one covering earthquake in Italy, studying its main features just seen and explained in this chapter.

Chapter 3

In this chapter an analysis of the features of Azzurro RE I Limited catastrophe bond will be provided, in particular with a view of the effects that the earthquake occurred in central Italy in August 24th, 2016 had on that cat bond.

Azzurro RE I Limited

While catastrophe bonds have been used a lot for example in the Americas or in Asia to move the risk of natural disasters, because of their common and major hurricanes and earthquakes, just a few of these bonds were issued in Europe, and none covering earthquakes in Italy. At least until 2015, when UnipolSai Assicurazioni S.p.A., which is the largest non-life insurer in Italy, brought to market the first catastrophe bond against seismic risk in Italy and nearer countries.

From here on, UnipolSai will be also referred as "ceding insurer".

3.1 UnipolSai overview

UnipolSai is a publicly traded company both in Milan and London Stock Exchange, which had a market capitalization of €6.43 billion at the time of the bond issuance, resulting from the merger by incorporation of the Fondiaria-Sai Group and Unipol S.p.A., becoming UnipolSai Assicurazioni S.p.A., with Unipol Group reaching the first rank in the market, being the largest non-life insurance company in Italy, with a market share moving around 20% of the Italian non-life insurance sector.

Recalling *table 1* in paragraph *2.2.3,* at the time of issuance of the catastrophe bond, the company was rated Baa2 by Moody's and BBB- by S&P.

It is interesting to notice how this company only provides earthquake coverage as an optional cover on property insurance policies, without selling earthquake coverage on a stand-alone basis.

UnipolSai assigns the policies forming the Subject Business[38] of the company to four different categories as follows:

- *Personal Lines Subject Business:* property and contents insurance written to individuals and classified as "Personal Lines" business;
- *SME[39] Subject Business:* property, contents and business interruption insurance written to companies and other entities – e.g. public sector entities – with less than 200 employees and annual revenue below €50 million and classified by the UnipolSai as "SME" business;
- *Corporate Subject Business:* property, contents and business interruption insurance written to companies and other entities – e.g. public sector entities – with annual revenue exceeding €50 million or more than 200 employees and classified by the UnipolSai as "Corporate" business;
- *Affiliate Subject Business:* intra-group reinsurance written to Incontra Assicurazioni S.p.A. and Liguria Assicurazioni S.p.A.[40].

---

[38] In insurance, the Subject Business is a shorthand way of expressing "business of the class, size and limitation" covered under a reinsurance agreement.

[39] Small and Medium Enterprises.

[40] Both Incontra Assicurazioni S.p.A. and Liguria Assicurazioni S.p.A. are companies part of Unipol Group.

Table 2 shows UnipolSai's Italian portfolio divided by risk type, both in terms of total insured value and of total indemnity limit.

Risk Type	Total Insured Value		Total Indemnity Limit		Number of Policies	
	Amount in €	**%**	**Amount in €**	**%**	**Amount in €**	**%**
Public entities	96,940,060,489	38.1%	8,208,714,223	11.8%	1,264	1.4%
Industrial	72,632,878,019	28.5%	29,065,857,653	41.8%	11,236	12.2%
Residential/Civil	48,100,599,893	18.9%	15,340,858,981	22.0%	41,117	44.6%
Commercial	18,354,907,726	7.2%	8,469,094,718	12.2%	8,950	9.7%
Mixed/Various(1)	7,335,699,919	2.9%	2,866,045,323	4.1%	3,595	3.9%
Photovoltaic	3,022,521,882	1.2%	1,932,127,417	2.8%	12,617	13.7%
Engineering	2,758,831,426	1.1%	1,044,424,802	1.5%	3,323	3.6%
Real estate leasing	2,348,494,840	0.9%	1,165,524,570	1.7%	2,717	2.9%
Agriculture	1,278,537,224	0.5%	442,318,677	0.6%	208	0.2%
Equipment leasing	805,893,380	0.3%	405,801,571	0.6%	4,337	4.7%
Electronics	463,767,996	0.2%	196,694,892	0.3%	987	1.1%
Real estate / equipment leasing	462,053,175	0.2%	316,748,031	0.5%	1,447	1.6%
Machinery	232,466,895	0.1%	116,233,447	0.2%	335	0.4%
IT	29,407,000	0.0%	14,703,500	0.0%	3	0.0%
Total(2)	**254,766,119,864**	**100%**	**69,585,147,805**	**100%**	**92,136**	**100%**

Table 2: Total insured value and total indemnity limit by risk type in Italy as of 31st December 2014.

(1) Refers to policies that cover more than one class of business; (2) Totals may not add due to rounding.

It is interesting to notice how residential/civil risk counts for the 44.6% of the number of the policies, but just 18.9% of the total insured value and 22.0% of the total indemnity limit, while industrial risk, which represents just the 12.2% of the policies, amounts to 28.5% of the total insured value and almost doubles the indemnity limit of residential/civic risk with 41.8%. Public entities risk total insured value is more than two times the one of residential/civic risk, but with half of its indemnity limit and just 1.4% of the number of policies.

The last relevant risk type is commercial risk, whose insured value represents 7.2% of the total with 9.7% of the number of policies and an indemnity limit that amounts to 12.2% of the total.

All the other (nine) risk types together reach just 7.1% of the total insured value, 12.3% of total indemnity limit, but almost one third of the number of policies.

Earthquake risk coverage is included in policies of different lines of business. Most of them are fire policies for the different risk types of *table 2*, so fire insurance policies covering public entities, industrial fire insurance policies covering business activities, agricultural fire insurance policies for agricultural industry, commercial fire insurance policies for offices and retail distribution with public access, and residential fire insurance policies.

Other lines of business including the cover of earthquake risk are insurance policies covering damages for real estate and equipment leasing risk for buildings and goods purchased through a leasing contract, and for machinery, photovoltaic, electronics and IT insurance policies, which cover machinery, equipment, plants and computers.

These insurance policies can be standardized products or tailor-made products. Standardized products represents 68% of the number of policies forming the Subject Business, but with a link to what seen in *table 2* for residential/civil risk type, they only represent 7% of the total insured value and 14% of the total indemnity limit. They are in fact dedicated mostly to Personal Lines Subject Business and also a little to SME Subject Business.

Tailor-made products mainly cover SME and Corporate Subject Business, with customers requiring bespoke coverage. These products, representing the remaining 32% of the number of policies forming the Subject Business, covers the 93% of the total insured value and 86% of the total indemnity limit forming the Subject Business.

The comparison between the two is shown in *table 3 below*.

Product Type	Number of Policies	Total Insured Value	Total Indemnity Limit
Standardized products	68%	7%	14%
Tailor-made products	32%	93%	86%
Total	**100%**	**100%**	**100%**

Table 3: Distribution of standardized and tailor-made products forming the Subject Business of UnipolSai.

In order to understand the risk analysis that will be provided in the next chapter, it is important to note that approximately two-thirds of the total indemnity limit of the ceding insurer is located in northern Italy, in particular Lombardia represents 31.6%, Emilia-Romagna 13.7%, Veneto 11.2% and Piemonte 10.1%. So these four regions alone represent more than 66% of UnipolSai's total indemnity limit in Italy.

3.2 Features of Azzurro RE I Limited catastrophe bond

For the issuance of this catastrophe bond, the Irish jurisdiction was chosen, and so an SPV was established in Ireland. The name “Azzurro Re I Limited” was chosen for this company, in order to give an immediate recall to Italy, as its national football team is globally known as “Azzurri”.

The catastrophe bond issuance was a great success. The bond was originally intended raise an amount of €150 million, and was instead later brought up to €200 million for the high request. It was reserved to professional investors only, In fact the minimum subscription was €250.000. The money was collected with orders that came from 23 different investors, none of whom from Italy, in particular Americans, British and Swiss investors.

More specifically, Azzurro RE I Limited provides to UnipolSai a totally guaranteed coverage for €200 million against earthquake peril and ensuing perils (such as fire, ground shaking, volcanic disturbance or eruption, tsunami, etcetera) with an initial attachment point of €500 million up to an initial exhaustion point of €700 million. This means that investors begin to lose money at €500 million ultimate net losses and lose all the money when the latter reach €700 million. The ultimate net loss is the financial obligation one party has, in this case UnipolSai, in the occurrence of an insured event, in this case an earthquake in the covered area.

Azzurro RE I catastrophe bond was issued the 17th of June 2015, with a duration of 3.5 years, so with maturity 16th of January 2019.

Proceeds raised from the issuance of the notes were deposited and are held in a Collateral Account for the benefit of UnipolSai and invested in the European Bank for Reconstruction and Development Notes (EBRD) with triple-A rating, offering a coupon of 3-month Euribor minus 38 basis points, with a minimum of zero.

Figure 9 provides a scheme of the relationships between the players of this catastrophe bond.

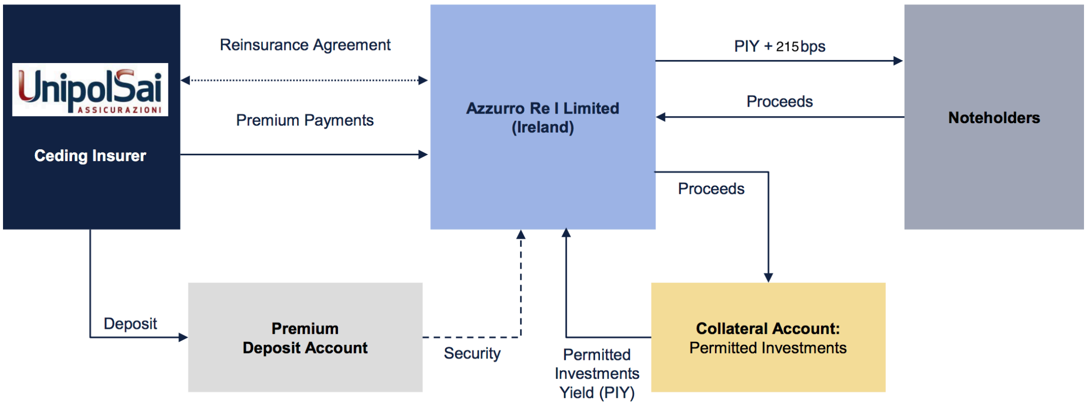

Figure 9: Scheme of Azzurro RE I Ltd. catastrophe bond

The covered area is predominantly located in Italy, considered perhaps the peak zone for what concerns earthquakes in continental Europe. However, UnipolSai is protected by the fully collateralized reinsurance protection provided by the cat bond, against losses from earthquakes occurring also in Corsica, metropolitan France (excluding overseas territories), Switzerland, Monaco, Austria and Slovenia.

Countries surrounding the covered area are included because the aim is to capture earthquakes that could occur in neighbouring countries but yet cause losses to UnipolSai's portfolio in Italy.

In other words, a covered event is an earthquake with a date of occurrence during the risk period and which causes losses within any part of the covered area.

For the avoidance of doubt, an earthquake the epicentre of which is outside of the covered area may nonetheless be a covered event. The ceding insurer may deem one or more subsequent earthquakes to be part of the same covered event as a first earthquake if, and only if, each such subsequent earthquake occurs within the duration of such first earthquake.

The duration of an earthquake means a period of seventy-two (72) consecutive hours as determined by UnipolSai, provided that such period shall include the date of occurrence of the earthquake in question. The latter is the starting date and time reported by the Earthquake Reporting Agency, which is stipulated by the contract to be: firstly the Italian "Istituto Nazionale di Geofisica e Vulcanologia" (INGV) or any successor thereto; in case the INGV ceases to exist or to provide earthquake information, the "European-Mediterranean Seismological Centre" (EMSC) or any successor thereto will substitute the INGV; in the event that also the EMSC ceases to exist or to provide earthquake information, then its place will be taken by the United States Geological Survey (USGS) or any successor thereto. In the very unlikely event that even this last figure ceases to exist or to provide earthquake information, the Reset Agent, in consultation with the ceding insurer, will choose another reporting agency for this role.

While the collateral account invested in EBRD notes at 3-months Euribor minus 38 basis points with minimum of zero, the coupon of this catastrophe bond is composed of the 3-months Euribor with minimum zero, plus the risk spread of 2.15% per annum, so the minimum coupon rate is 2.15%.

Chart 4 shows the trend on daily basis from January 2014 to late August 2017 of the return rate of: the 3-months Euribor, and the 10-years Italian BTP, and the Generic Eurozone 10-years Government, which is used in Europe as a benchmark for the risk-free return rate, as it is one of the lowest in general and the lowest among super liquid securities.

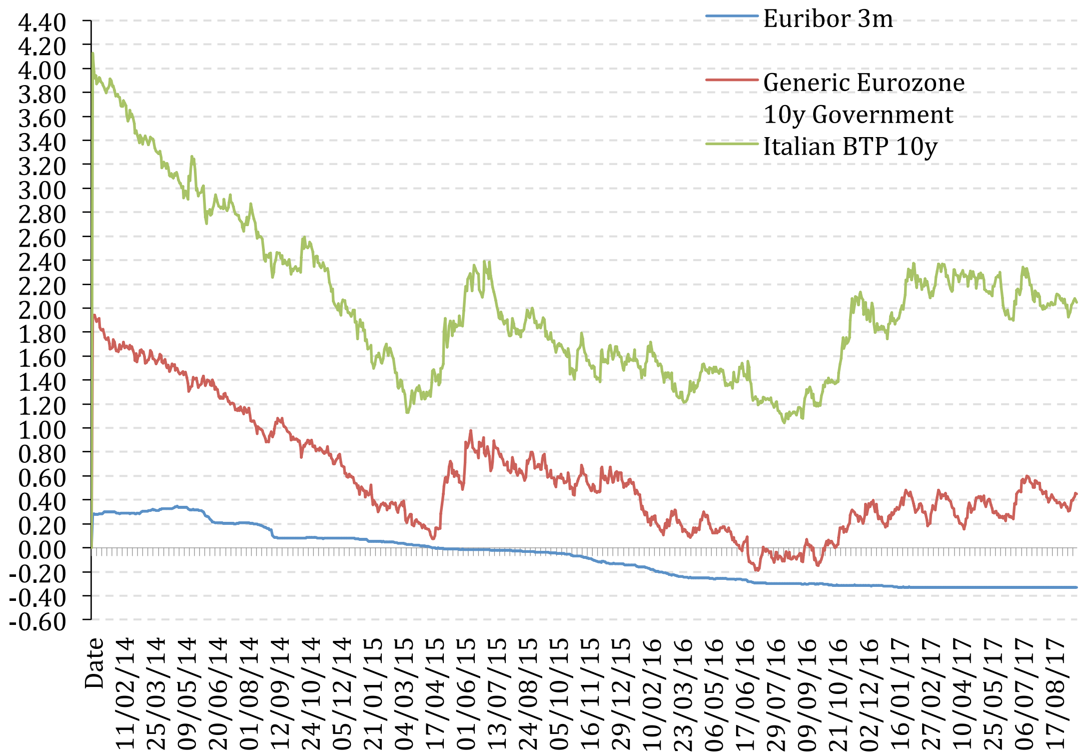

Chart 4: Interest rate trends comparison.

The first thing to notice regarding this catastrophe bond, is that the 3-months Euribor has been negative since late April 2015, and has never risen positive again yet. This means that the return of the collateral account is zero and the investor's coupon of the catastrophe bond has always been the minimum 2.15%, as noticeable in the column of the last coupon payments in *figure 10,* taken from Bloomberg.

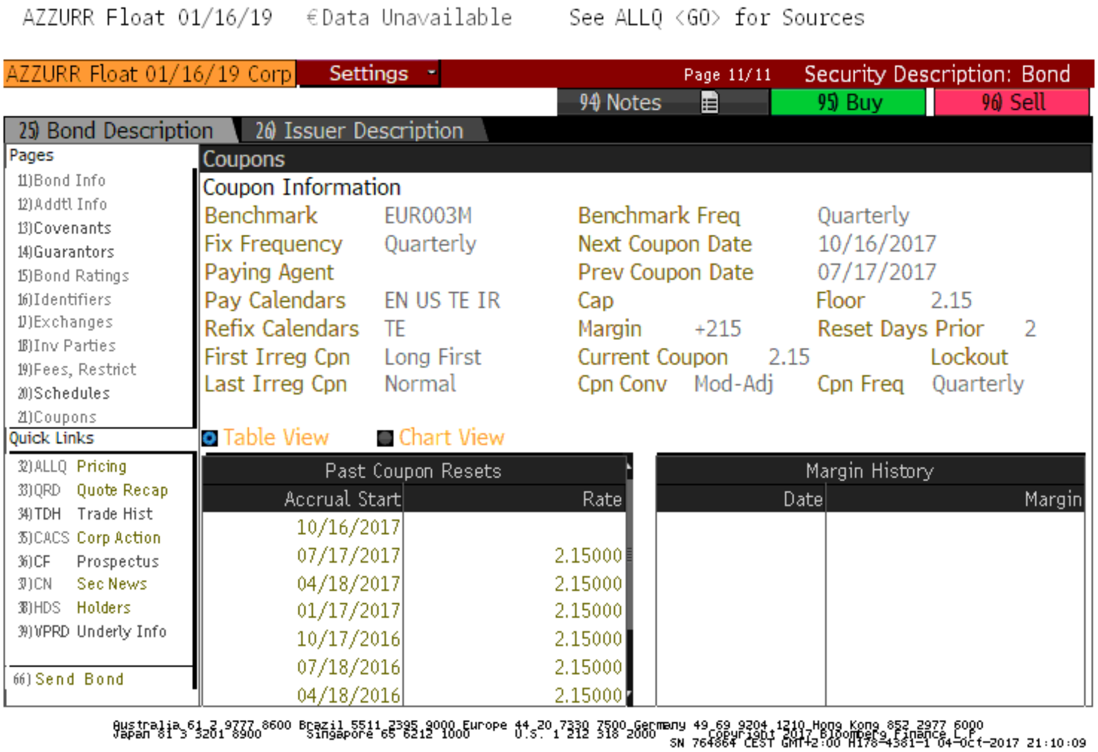

Figure 10: Bloomberg Azzurro RE I Ltd. bond description and last coupon payments.

This 2.15% spread is quite low if compared to other cat bonds, in fact it was the fifth lowest risk spread in cat bond history. To have an element of comparison, a similar $150 million cat bond of the same period with indemnity trigger on hurricanes in Florida, has an expected loss of 1.41% and a risk interest spread of 4.75% per annum.

By the way Azzurro RE I Ltd., as shown in *chart 5*, has the highest ratio between the coupon spread and the expected loss, 6.9x, among cat bonds issued in 2015 until June (exception made for Kizuna RE II Ltd. Which has a 11.1x ratio).

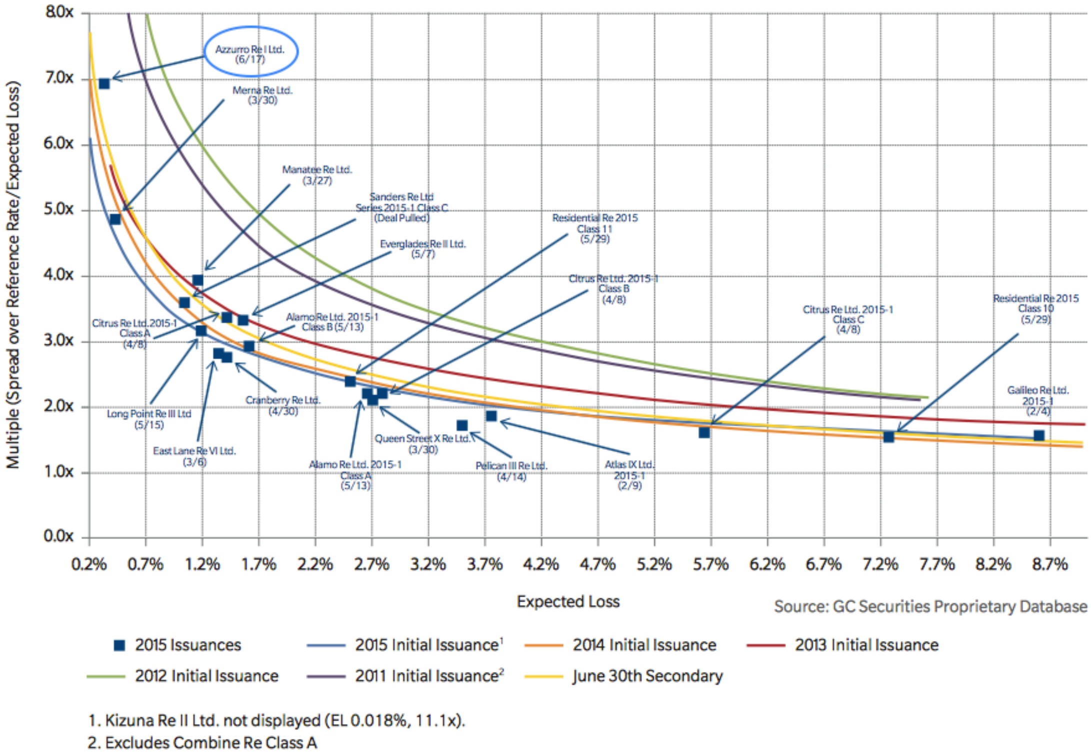

Chart 5: Spread over Expected Loss ratio of 2015 cat bond issued until July 30th, 2015.

The reasons of this risk spread to be as low as 2.15% are the attachment probability, the exhaustion probability and the expected loss, whose values for this bond are to be explained in the next paragraph.

3.2.1 Risk analysis, probabilities and estimations

Even if there had been a few cat bonds that have securitised European flood and windstorm risks in the past, none have done so for earthquakes and none covering only Italy. In particular none has done so on an indemnity trigger basis like Azzurro RE I Ltd. catastrophe bond did.

One particular issue of this bond is that, even if the bond has an indemnity trigger basis as stated before, the risk analysis, the probabilities and the estimations were computed as it would has been done with a modeled loss index trigger (see paragraph *2.1.1*).

There are three main model used in catastrophe bond sector, which are AIR, RMS and RQE[41]. At the moment of the issuance, RMS and RQE were under review of the "Istituto per la Vigilanza sulle Assicurazioni" (IVASS), the supervisor body for insurance companies, so their models were only available for issuances with maximum duration of one year. Needing a 3.5-year duration for this cat bond, the model and estimations were then provided by AIR Worldwide Corporation (AIR), whose model was the only one not under review. AIR used their own software and risk models with the latest versions[42] of their own model used to provide European risk analysis, whose name is "Earthquake Model for the Pan-European region", for the risk analysis and estimations of this cat bond.

The model response, based on 10,000 simulations, gave as results that the risk of this catastrophe bond was quite low. In particular the attachment probability for the notes was 0.44%, the exhaustion probability was 0.22%, and the expected loss was 0.31%. This means that:

- the probability that the triggered event would have occurred, and so that investors would have started losing money, was 0.44%;

[41] AIR, RMS and RQE are companies that analyse information assets and data to provide clients with analytics and customized data services, also developing proprietary research, tracking current and historical trends in a several categories, including natural hazards, and disaster projections.

[42] AIR proprietary software and risk models implemented in Touchstone 2.0.2 and Catrader 16.0 which includes version 3.0 of their "Earthquake Model for the Pan-European region" mentioned in the text, lastly updated in 2011 before the cat bond issuance.

- the probability that the triggered event would have occurred, and so that investors would have lost all the money, was 0.22%;
- investors were likely to lose 0.31% of the money invested.

Also other third-party modeling firms were involved, and their results did not indicate different levels of attachment and exit probability or expected loss. This data confirmed Azzurro RE I catastrophe bond as a reasonably low risk cat bond. For this reason, the risk interest spread was set at only 2.15% per annum.

The above mentioned model used by AIR, just modeled the peril of Earthquake ground shaking, implementing as parameters the magnitude, the location, the rupture length, width and depth, and the fault orientation.

It did not include in model only the countries covered in the cat bond, so, in addiction to Italy, France (comprising Corsica and excluding overseas territories), Monaco, Switzerland, Austria and Slovenia, it included also Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Israel, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Sweden, Turkey, and the United Kingdom.

During the local ground shaking intensity calculations, the model considered the local site conditions that characterize site amplification or attenuation factors, with damages computations based on local construction, occupancy, number of stories, and year of construction of the buildings.

Since the catastrophe bond covers risk only for losses on Italy, the model kept into consideration the modeled exposure in Italy by zones, as shown in *figure 11* below.

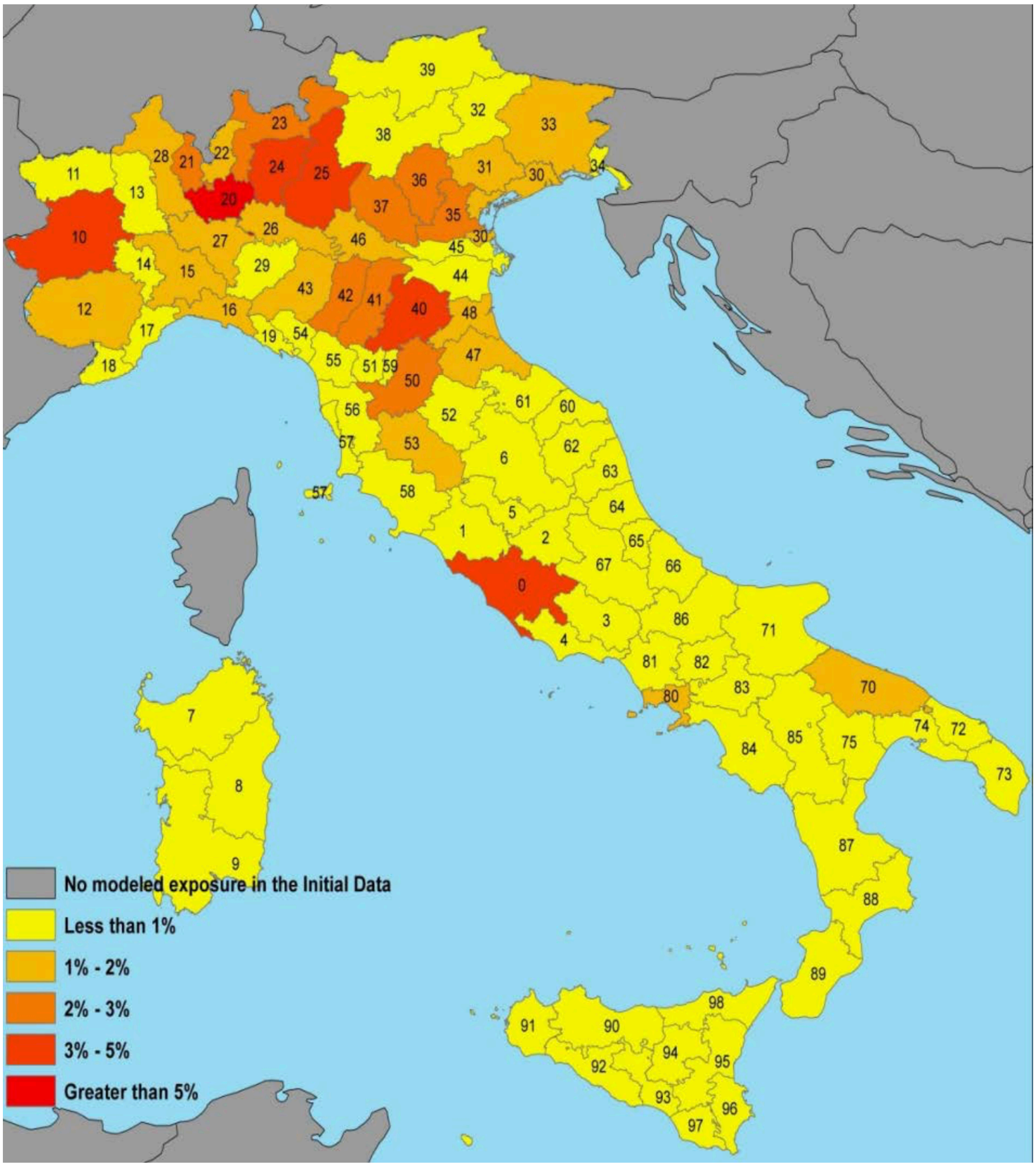

Figure 11: Distribution of modeled total insured value and total indemnity limit.

These data were and still are provided by CRESTA, an organisation established by the insurance and reinsurance industry in 1977 as an independent body for the technical management of natural hazard coverage.

CRESTA's main tasks are:

- determining country-specific zones for the uniform and detailed reporting of exposure data usually relating to natural hazards;

- promoting a template to exchange exposure data in the industry;
- offering a mapping service to visualize values based on CRESTA zones.

All the areas in which Italy is divided in *figure 11* are not Italian regions or provinces, but they are in fact CRESTA zones.

Table 4 below shows instead the distribution of the total insured value and the total indemnity limit always by CRESTA zones, which you can check in *figure 12* to which region they refer.

CRESTA zone	Total Insured Value € in million	Total Indemnity Limit	
		Amount in €	%
20	29,553	9,125	13.2%
0	26,086	3,310	4.8%
10	12,826	3,276	4.7%
25	8,521	3,106	4.5%
24	7,671	2,649	3.8%
40	10,200	2,414	3.5%
41	5,793	1,964	2.8%
37	7,336	1,924	2.8%
35	4,155	1,062	2.3%
23	5,192	1,530	2.2%
36	4,908	1,524	2.2%
21	4,835	1,479	2.1%
50	4,438	1,471	2.1%
42	4,026	1,457	2.1%
16	5,490	1,259	1.8%
31	4,049	1,234	1.8%

22	3,352	1,229	1.8%
33	3,160	1,209	1.7%
12	3,092	1,055	1.5%
30	4,203	1,048	1.5%
Others	93,356	25,347	36.6%
Total	**252,242**	**68,672**	**100%**

Table 4: Distribution of Modeled Total Insured Value and Total Indemnity Limit.

The model did take in consideration also the construction class of the insured buildings as shown in *table 5* below.

CRESTA zone	Total Indemnity Limit € in million	Proportion of Total Indemnity Limit (%)
Reinforced concrete	45,143	65.2%
Masonry	14,609	21.1%
Steel	9,458	13.7%
Total	**69,210**	**100.0%**

Table 5: Distribution of Modeled Total Indemnity Limit by Construction Class.

Considering all these and other proprietary and classified data, AIR estimated that 85% of the modeled expected loss was attributed to the four northern regions mentioned in the previous chapter, so Lombardia, Emilia Romagna, Veneto and Piemonte; the remaining 15% was shared by all the rest of Italy.

These contributions to the modeled expected loss are summarized in *figure 12* and in *table 6* by region, and in *figure 13* and *table 7* by CRESTA zones.

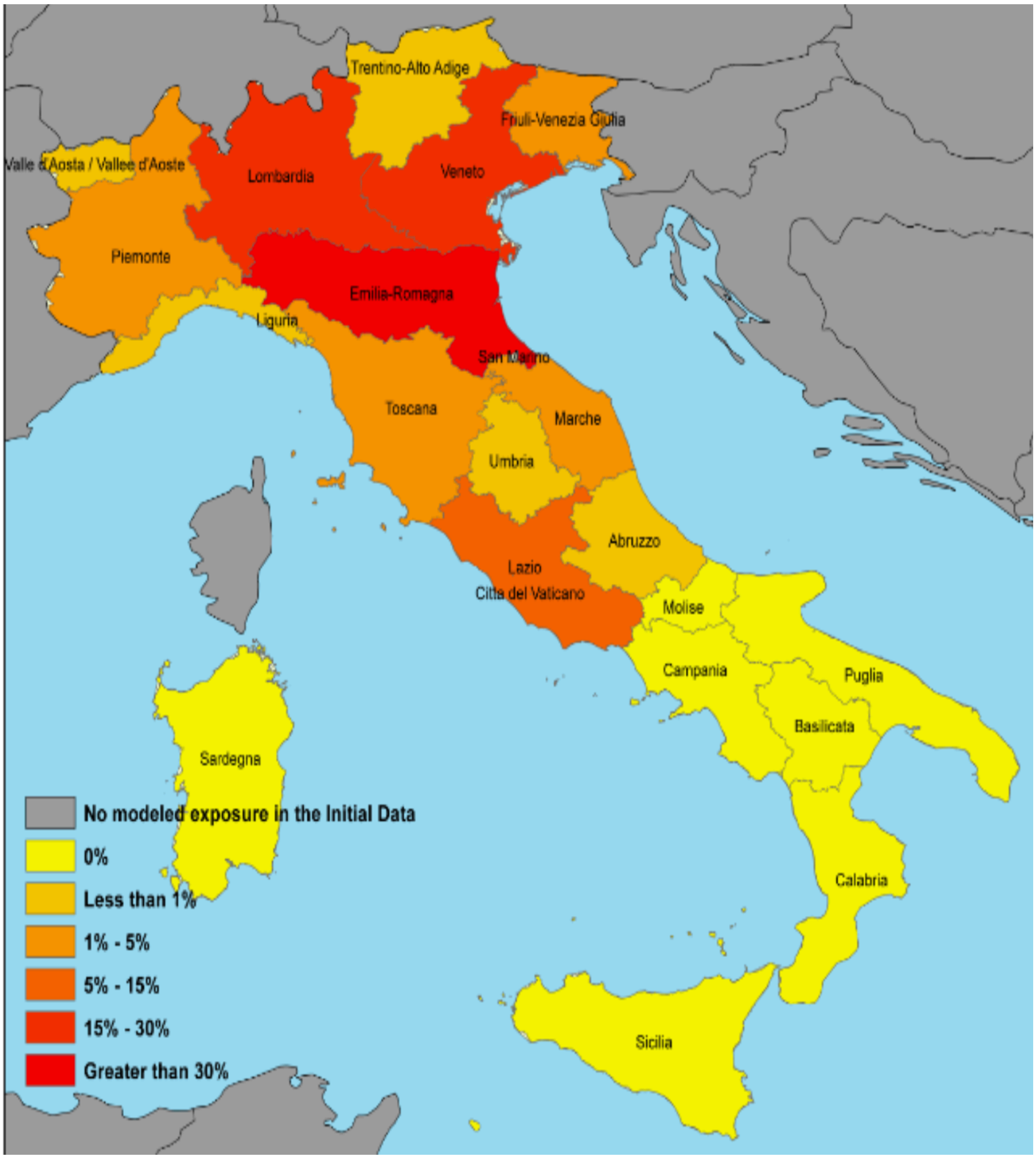

Figure 12: Contribution to the initial modeled expected loss by region for the notes**.**

The figure and the table clearly show that northern Italy gives a big contribution to the initial modeled expected loss.

Region	Contribution to Initial Modeled Expected Loss (%)
Emilia-Romagna	34.7%
Lombardia	26.2%
Veneto	21.5%
Lazio	6.4%
Toscana	3.2%
Piemonte	2.6%
Friuli-Venezia Giulia	2.4%
Marche	1.2%
Liguria	0.8%
Trentino-Alto Adige	0.8%
Umbria	0.2%
Abruzzo	<0.1%
Valle D'Aosta	<0.1%
Total	**100%**

Table 6: Contribution to the initial modeled expected loss by region for the notes.

Regions not present in *table 6,* that are in yellow in *figure 12,* do not contribute to the initial modeled expected loss because the ceding insurer has a very light activity and is lightly present in southern Italy; these regions were the company is almost absent are Campania, Puglia, Sicilia, Sardinia, Calabria, Basilicata, and Molise. This is confirmed also by CRESTA zones shown in *figure 13* and *table 7*, where there are thirty-two (32) non-contributing CRESTA zones, almost all in southern Italy and islands.

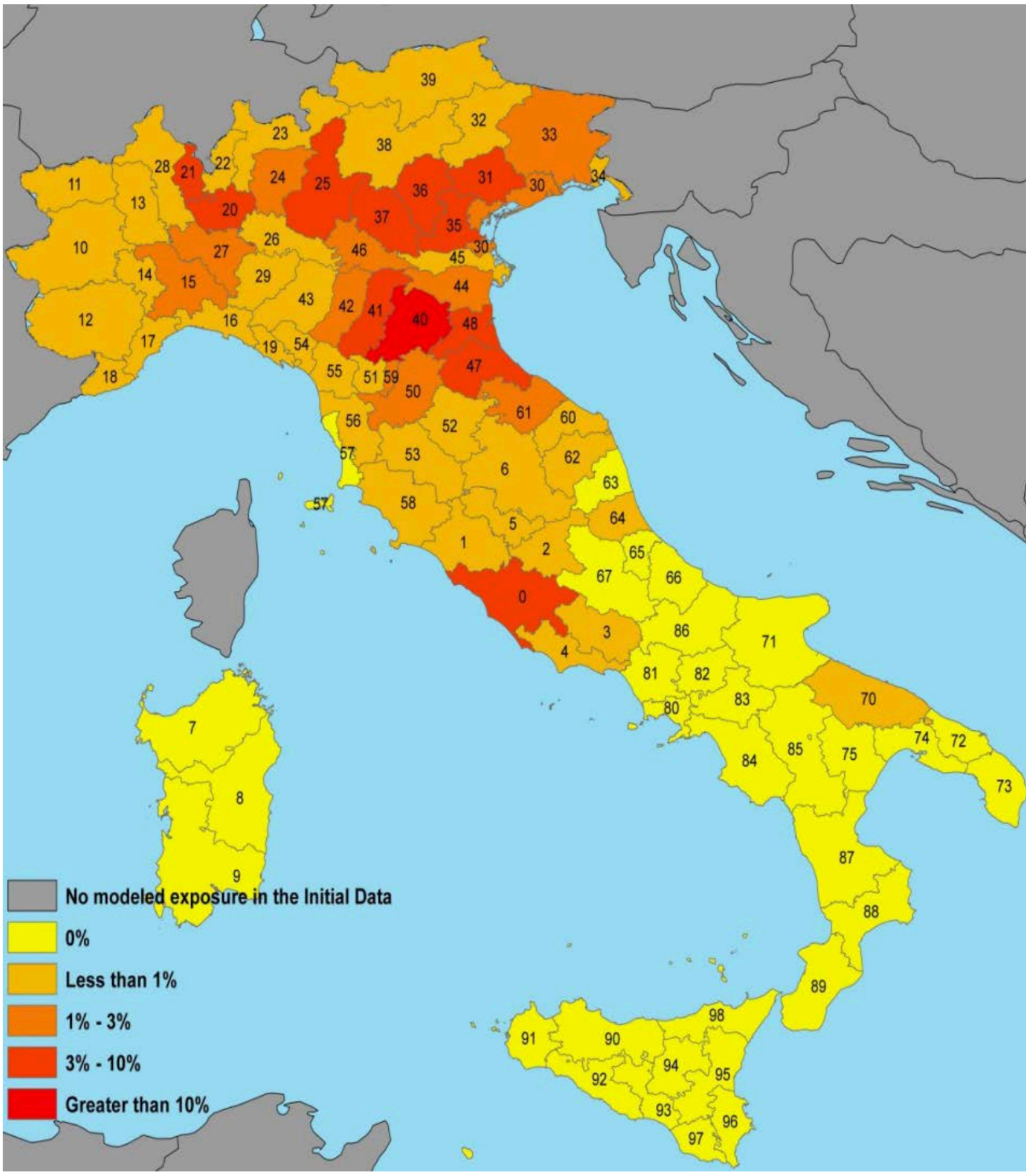

Figure 13: Contribution to the initial modeled expected loss by CRESTA zone for the Notes.

CRESTA zone	Contribution to Initial Modeled Expected Loss (%)
40	13.2%
20	8.9%
41	7.2%
25	6.6%
0	6.4%
47	6.3%
21	5.7%
36	5.6%
37	5.5%
31	4.7%
48	4.3%
35	3.8%
33	2.3%
42	1.4%
30	1.4%
50	1.3%
46	1.3%
27	1.2%
15	1.2%
59	1.1%
Others	10.6%
Total	**100.0%**

Table 7: Contribution to the initial modeled expected loss by CRESTA zone for the Notes.

For what concerns the magnitude of the earthquakes, the model took into consideration measurements reading below 6.0, between 6.00 and 6.49, between 6.50 and 6.99 and then over 7.0. Since earthquakes with magnitude over 7.0 are rare – especially in Italy where the last earthquake with a magnitude in excess of 7.0 occurred in Avezzano (L'Aquila, Abruzzo) in 1915 – the two middle ranges contributed respectively 36.0% and 56.5% of the modeled expected loss (92.5% total). This contribution to modeled expected loss by magnitude is shown in *table 8* below.

Magnitude (Mw)	Contribution to Initial Modeled Expected Loss (%)
Mw < 6.0	4.3%
6.0 ≤ Mw < 6.5	36.0%
6.5 ≤ Mw < 7.0	56.5%
Mw ≥ 7.0	3.2%
Total	**100%**

Table 8: Contribution to modeled expected loss by magnitude.

In order to obtain the values of attachment probability and exhaustion probability, AIR's proprietary software simulated earthquakes of different intensity (magnitude, only considering ground shaking) and with different epicentre. Then, the model computed the eventual losses for each scenario considering the whole area covered by the catastrophe bond, in terms of Modeled Industry Insured Loss, Modeled Industry Insured Loss in Italy and Modeled Ultimate Net Loss. The first two values by the way do not affect the notes; the value that investors look at is the last one, the ultimate net loss. From this value in fact depends if the event triggered or not the cat bond.

Table 9 shows, in a stochastic loss distribution sample, how earthquakes would affect the bond, depending on the magnitudes of several earthquakes with epicentres set in different locations, and on the probability of occurrence of each of these events, according to AIR.

	Modeled Annual Probability of Exceedance[1] (%)	Epicentre (CRESTA zone, region, Country)	Magnitude (Mw)	Modeled Industry Insured Loss in the Covered Area (€ bn)	Modeled Industry Insured Loss in Italy (€ bn)	Modeled Ultimate Net Loss (€ mln)	Modeled Notes Principal Reduction (%)
Exhaustion level	0.10%	Z41, Emilia-Romagna, Italy	6.5	6.3	6.3	1,092.2	100%
	0.15%	Z00, Lazio, Italy	6.2	9.1	9.1	875.8	100%
	0.19%	Z47, Emilia-Romagna, Italy	6.9	5.7	5.7	786.2	100%
	0.21%	Z40, Emilia-Romagna, Italy	6.0	4.3	4.3	718.3	100%
	0.22%	Z32, Veneto, Italy	7.0	6.6	6.5	709.9	100%
Attachment level	0.23%	Z21, Lombardia, Italy	6.1	7.2	7.2	699.6	>99%
	0.24%	Z25, Lombardia, Italy	6.0	3.6	3.6	690.6	95%
	0.28%	Z32, Veneto, Italy	6.8	5.9	5.8	643.7	72%
	0.32%	Z40, Emilia-Romagna, Italy	6.5	3.3	3.3	586.8	43%
	0.35%	Z20, Lombardia, Italy	5.6	2.9	2.9	578.4	39%
	0.39%	Z48, Emilia-Romagna, Italy	6.4	4.0	4.0	514.2	7%
	0.40%	Z46, Lombardia, Italy	6.2	2.8	2.8	503.9	2%
	0.41%	Z33, Friuli-Venezia Giulia, Italy	7.0	4.9	4.2	488.0	0%
	0.42%	Z80, Campania, Italy	6.7	9.3	9.3	485.5	0%
	0.44%	Z25, Lombardia, Italy	6.1	2.7	2.7	478.3	0%
	0.50%	Z37, Veneto, Italy	6.1	2.6	2.6	454.8	0%
	0.63%	Z10, Graubünden, Switzerland	7.3	19.2	2.3	397.2	0%

Table 9: Sample Simulated Stochastic Years Loss Distribution for the Notes.

(1) It is an estimate of the likelihood that the level of modeled Ultimate Net Loss to the Notes associated with a given year will be exceeded in any given simulated year.

The table is divided horizontally into three main sectors: the one on the top including earthquakes which exceed the exit point of the bond, the middle one including events that exceed the attachment point but not the exhaustion point, and the bottom sector that includes earthquakes which would not affect the notes of the catastrophe bond.

It is easy to notice that the exceedance probability of the borders between the sectors mirrors the values mentioned before of the attachment and exhaustion point. This because, looking at the two last columns of the table, those are the points that exceed the €500 million of the attachment point and the €700 million of the exit point, with the related percentage of loss for each case. The percentage of loss in fact exceeds 0% and 100% respectively with 0.41% and 0.22% probability, which are exactly the attachment and exhaustion points respectively.

AIR model also provided a simulation applying this catastrophe bond to historical Italian earthquakes, with the results shown in *table 10*. Also in this case the table shows the epicentre and the magnitude of these real earthquakes of the past, and the loss they would have caused, considering the present portfolio of UnipolSai.

It is immediate to notice that even the strongest and most devastating earthquakes occurred in the last two centuries of Italian history would have never affected Azzurro RE I Ltd. catastrophe bond.

This is the confirmation that this cat bond is a relatively low risk bond, with the probability of occurrence of a triggering event of one every three hundred years.

Event	Year	Epicentre (CRESTA zone, region, Country)	Magnitude (Mw)	Modeled Industry Insured Loss in the Covered Area (€ mln)	Modeled Industry Insured Loss in Italy (€ mln)	Modeled Ultimate Net Loss (€ mln)	Modeled Notes Principal Reduction (%)
Irpinia	1980	Z83, Campania, Italy	6.9	5,279.3	5,279.3	291.1	0%
Avezzano	1915	Z00, Lazio, Italy	7.0	1,700.7	1,700.7	193.9	0%
Friuli	1976	Z33, Friuli-Venezia Giulia, Italy	6.4	1,973.7	1,973.7	162.5	0%
Messina-Reggio	1908	Z89, Calabria, Italy	7.1	2,047.9	2,047.9	44.8	0%
Ligurie	1887	Z18, Liguria, Italy	6.3	554.1	554.1	33.1	0%
Umbria – Marche	1997	Z06, Umbria, Italy	6.1	461.3	461.3	24.2	0%
Perugia	1984	Z06, Umbria, Italy	5.6	45.4	45.4	10.6	0%
L'Aquila	2009	Z67, Abruzzo, Italy	6.3	255.9	255.9	7.8	0%
Ligurie	1854	Z18, Liguria, Italy	5.8	1152.6	1152.6	6.7	0%
Valle Del Belice	1968	Z91, Sicilia, Italy	6.5	401,9	401,9	5.3	0%
Visp	1855	Z24, Wallis, Switzerland	6.4	637.1	49.7	4.7	0%
Lake Garda	2004	Z25, Lombardia, Italy	5.0	13.9	13.9	4.2	0%
Molise	2002	Z86, Molise, Italy	5.8	24.7	24.7	0.6	0%
Abruzzo	1984	Z03, Lazio, Italy	5.8	12.6	12.6	0.6	0%
Sicily	1990	Z96, Sicilia, Italy	5.7	24	24	0.6	0%
Sicily	2002	Z90, Sicilia, Italy	5.9	17.4	17.4	0.1	0%
Bovec	1998	Z01, Slovenia	5.67	14.1	0.9	0.1	0%
Bovec	2004	Z01, Slovenia	5.2	1.8	<0.1	<0.1	0%

Table 10: Modeled results for historical earthquake events for the notes.

Given this risk analysis and all the procedures explained in *chapter 2.3.3*, the rating agency Fitch rated Azzurro RE I Ltd. cat bond BB+, so, according to *table 1*, corresponds to a “Non Investment Grade Speculative” security.

3.3 Central Italy earthquake of August 24th, 2016

After L’Aquila earthquake in 2009 (see *table 10*) and Emilia earthquake in 2012, central Italy was victim of another earthquake in 2016.

The first strong shock occurred on August 24th, and had a magnitude of 6.0. Two powerful replicas took place on October 26th and the strongest shock occurred in October 30th, where a 6.5 magnitude was recorded. In January 18th, 2017, a new sequence of four strong shocks with magnitude greater than 5, with a maximum of 5.5, occurred. The occurred earthquakes had epicentre located along Abruzzo, Lazio, Marche and Umbria, in places that are between CRESTA zones 64, 65 and 67 in *figure 11* and in *figure 13*.

3.3.1 Loss and effects on the notes

This sequence of earthquakes occurred in central Italy was covered by Azzurro RE I Ltd. catastrophe bond. As explained in the UnipolSai overview in chapter *3.1*, the insurance company has a market share that fluctuates around 20% in the non-life insurance sector. In particular, when the earthquakes occurred, UnipolSai’s Italian market share was 23.2%, and more specifically, as shown in *table 6*, the contribution to the initial modeled expected loss of the company in the affected area was 0.1% in Abruzzo, 0.2% in Umbria, 1.2% in Marche and 6.4% in Lazio, for a total of 7.9%. In addiction there was an approximate 14% P&C (“Property & Casualty”) insurance penetration in that area.

The earthquakes caused losses for an estimated amount between €4 and €5 billion, which are quite higher than damages caused by L’Aquila earthquake in 2009, that amounted approximately to €2.5 billion.

The P&C insurance penetration as limited as 14% in the affected area, combined with the local 7.9% modeled expected loss of UnipolSai, made the cat bond not to be affected by these disastrous events occurred during the bond duration. A simple sequence of linear computations presented below explains it calculating the assumed insured loss value and the assumed UnipolSai's exposure.

Considering losses set at €4.5 billion, which is half way between the €4 to €5 billion loss estimation, and the P&C insurance penetration of the affected area as low as 14%, the product of the two results in an estimation of the assumed P&C insured loss whose value is €630 million.

$$Economic\ losses \times P\&C\ insur.local\ penetration =\ Assumed\ insur.loss$$

The assumed value of UnipolSai exposure results from the product between the assumed P&C insurance loss just computed and UnipolSai's P&C modeled expected loss at the moment of occurrence of the earthquakes, which is 7.9%. The result is €49.8 million.

$$Assumed\ insur.loss \times Unipol's\ modeled\ exp.loss =\ assumed\ UnipolSai'exposure$$

In addiction, ultimate net loss is calculated by applying some adjustment factors, which are not available since they are proprietary of AIR's model. These factors further reduce the assumed exposure just computed, providing an ultimate net loss of €40 million.

If this last value was higher than the attachment point, the bond would have been triggered, but it was not.

Given these computations, *table 11* provides a simulation with nine different loss scenarios of an earthquake occurred in the same region as the one occurred in August 24th, 2016.

Loss scenario 1 – written in blue – represents real data losses. All the other loss scenarios are assumptive and unreal situations to understand how massive losses should have been to trigger Azzurro RE I Ltd. catastrophe bond.

Loss scenario	1	2	3	4	5	6	7	8	9
Economic losses (€ mln)	4.5k	10k	20k	30k	40k	45,2k	50k	51.9k	63.3k
Assumed P&C insur. penetration	14%								
Assumed insur. Loss (€ mln)	630	1,400	2,800	4,200	5,600	6,329	7,000	7,278	8,861
UnipolSai P&C modeled exp. loss	7.9%								
UnipolSai assumed exposure (€ mln)	49.8	110.6	221.2	331.8	442.4	500	553.0	575	700
Cat bond attach. point (€ mln)	500								
Triggered value	450.2	389.4	278.8	168.2	57.6	0	-53	-75	-200

Table 11: Simulation of different loss scenarios with respect to insurance penetration and UnipolSai's modeled expected loss.

See that loss scenarios from 2 to 5 are below the attachment point, which is exceeded starting from the sixth loss scenario. This last situation represents, according to the above computations, the minimum total losses needed to trigger the bond; this minimum loss value amounts to €45.2 billion.

Scenarios from 6 to 9 represent instead situations in which the cat bond would have been triggered, always according to the calculations shown before. The ninth scenario represents specifically the case in which losses would cause non only the bond to be triggered, but also the exceedance of the exit point and so the total loss of the investors. Losses should amount €63.3 billion to reach this situation.

As said before, these computations do not consider the proprietary adjustment factors applied by AIR, which would further reduce the actual ultimate net loss. This means that the minimum total losses to be reached to exceed the attachment and the exhaustion points would have been even higher than the €45.2 and €63.3 billion computed.

These massive losses needed to trigger Azzurro RE I Ltd. catastrophe bond confirm the fact that this is a relatively low risk security.

In addiction, in January 2017, the attachment point of the cat bond was reset in order to maintain the risk constant, and was raised up to €575, which in *table 11* is triggered in the eighth loss scenario always not considering AIR's adjustment factors, value that will be reached with a total loss of almost €60 billion.

Even if not taking into account the adjustment factors of AIR, the computations just provided seems to be quite reliable according to the real ultimate net loss, in fact the difference between the two is just the 19.6%, which can be considered quite low for the little data available to make an estimation.

Moreover, even considering the almost 20% range of error coming from the difference between the real ultimate net loss and computed one, the computations made seem to be reliable in providing an order of magnitude of the values needed to be reached. This makes it is very unlikely that the new attachment point will be triggered in the future because of the approximately €60 billion loss needed to be reached, which seems almost impossible in the affected area.

Looking at it from the investor's perspective, this bond has been a good investment until now and it is supposed to be so until maturity.

This because even out of a loss of more than €4 billion, the actual ultimate net loss was "just" €40 million, which is quite far from the attachment point, making investors' 2.15% coupon to be constantly distributed as confirmed by *figure 10*.

Making the inverse reasoning and trying to have a hypothetical order of magnitude of investors' losses in the case a triggering event had occurred, the last line of the table provides the difference between the attachment point (the starting €500 million attachment point) and the assumed UnipolSai's exposure computed.

The low attachment probability will very likely let investors continue to receive the minimum 2.15% coupon until maturity, making both them and UnipolSai satisfied of the investment and of the issuance.

3.4 Future development

According to Mr Marc Guy Victor Sordoni, the person that can be considered the "father" of Azzurro RE I Limited catastrophe bond, Head of Reinsurance of UnipolSai Assicurazioni and Chief Executive Officer of UnipolRe Riassicurazioni[43], the satisfaction of both the company and the investors will very likely lead to new catastrophe bond issuances in the future of UnipolSai.

The two main reasons are indeed the investors and UnipolSai's satisfaction, and the very good effectiveness of the model for both parties.

In July 2017, also Assicurazioni Generali S.p.A., who had already issued

[43] UnipolRe was established in December 2014 as a professional reinsurer, with headquarters in Dublin, Ireland. As a subsidiary of UnipolSai Assicurazioni, UnipolRe provides reinsurance coverage to small and medium-sized insurance companies in Europe.

Lion I Re Ltd. cat bond in April 2014 covering European windstorm, has issued Lion II Re Ltd., the first European multi-peril catastrophe bond. It provides to Generali a €200 million coverage for four years from Europe windstorms, Europe flood, and earthquakes affecting Italy. It has several attachment points: €800 million for European windstorm losses, €1.1 billion for European flood losses, or €600 million for Italian earthquake losses suffered by Generali. It seems that the full EUR 200 million coverage should be just for windstorm and earthquake, while flood coverage should only be covered for €100 million layer of reinsurance protection.

That means the €200 million of notes issued by Lion II Re will have an initial attachment probability of 3.21% and an expected loss of 2.24%, while offering 3% coupon.

According to the "father" of Azzurro RE cat bond, Mr Sordoni, also the next UnipolSai's catastrophe bond will probably provide multi-peril coverage, in order to raise the risk and, as a consequence raise, the yield, maybe lowering also the trigger for what will probably be Azzurro RE II Ltd. catastrophe bond.

Conclusions

This thesis has pointed out that catastrophe bonds, not widely spread in Europe and especially in Italy, are a valid solution to prevent the risk that an insurance company could not face the losses due to unpredictable devastating natural events.

In the first chapter, CDSs and CDOs have been explained, with a focus on their hedging utility, showing that they offer different ways to diversify the portfolio, but yet having almost the same purpose: risk transfer. This worked as a basic introduction to catastrophe bonds, the main topic of the thesis.

The second chapter offered a description of the main features of this type of security. After an initial first section to introduce cat bond and their development, the central part of the chapter was dedicated to the description of all the phases needed for the issuance of these securities and to the explanation of how they work and their behaviour.
Here, all the features needed to better understand the real case of the third chapter are described, such as the different kind of triggers and the yields; a particular attention was dedicated to the valuation of cat bonds and the main points that determine it, as well as catastrophe bond rating and the procedure followed by rating agencies for these type of securities. The final part of the chapter was developed to explain the drivers of a significant decision to be taken in the issuance of a cat bond: the choice of the jurisdiction for the establishment of the Standard Purpose Vehicle. This section analyses all the principal issues to take into consideration for this decision.

The third chapter describes and analyses the first ever catastrophe bond issued to cover earthquake risk in Italy.
Firstly, a brief description of UnipolSai, the insurance company that brought this

kind security in Italy is provided, with an analysis of its market situation in the country, in order to understand how a catastrophe bond could have been affected by the occurrence of an earthquake.

Then, the conditions of all the features described in the second chapter are explained for this bond, named Azzurro RE I Limited, focusing on the risk analysis provided by the model developed by the specialized company AIR Worldwide Corporation. In this analysis several simulation of this model were offered, taking into consideration all the aspects of UnipolSai's portfolio in Italy described in the first part of the chapter. A simulation was also provided taking into consideration the present situation of the insurance company, but applying the model to the most severe and devastating documented earthquakes of Italian recent history. These simulation showed that even the strongest and most devastating Italian earthquake, which occurred in Irpinia (Campania) in 1980, would not had triggered Azzurro RE I Ltd. cat bond, with an ultimate net loss that was had been just 3/5 of the minimum loss needed to reach the attachment point of the bond and cause losses to the investors.

The third part of the chapter focused on the earthquake occurred in August 2016 in central Italy, so during the coverage of the catastrophe bond, and its effects on the security.

UnipolSai's portfolio and relative exposure was then reduced to the Italian regions affected by the earthquakes and, considering an approximate 14% P&C (Property and Casualty) insurance penetration in the area in that moment, an estimation of the losses that an earthquake in that specific location would have needed to cause to trigger the bond was provided.

Computations showed the massive losses needed to affect the attachment point of the catastrophe bond: that value, according to the calculations amounted to €45.2 billion just for the minimum loss suffered by investors, while €61.5 would have caused the total loss for investors.

Since this calculation method estimated an ultimate net loss of €49.8 million

when the actual value was €40 million, the computations can probably be considered quite reliable.
This confirms the low riskiness of this cat bond, which is unlikely to be triggered in the future until maturity for its very high attachment point.

After becoming widely spread in the Americas and in Asia, catastrophe bonds seem to have a bright future also in Italy, as Generali Assicurazioni S.p.A., after the 2014 positive issuance of a cat bond covering European windstorm, in 2017 has issued a new multi-peril catastrophe bond covering also earthquake in Italy.

The great success of Azzurro RE I Ltd. makes Mr Sordoni, the "father" of this catastrophe bond, think that UnipolSai's is very likely to issue new cat bonds in its future, offering multi-peril coverage with lower attachment point and higher yields to raise investors' coupons.

In a nation like Italy, where unluckily the very majority of the population believes that, in case of very unfortunate natural events, the government will provide to everything and everyone even if it is obviously not possible, a financial tool such as catastrophe bonds are probably a good answer to this very problematic popular thought, preventing the possible default of insurance companies in case of a destructive natural disaster.

The default of insurance companies would have devastating effects on a nation's economy and population, almost like a bank default would have. Catastrophe bonds might be a possible solution also for this socio-economic perspective, in particular in an earthquake-prone country as Italy.

Bibliography

Anger C., Brown J., Clarke R., Hum C., Yim S. (2015): "Catastrophe bond update: second quarter 2015"

Anger C., Brown J., Clarke R., Hum C., Yim S. (2015): "Catastrophe bond update: third quarter 2015"

Baglioni F., Scarpitti M. R. (2016): "I cat bonds nella gestione dei rischi catastrofali"

Bodoff, N.M., Gan Y. (2009) "An Analysis of the market price of Cat Bonds"

Boonstra S., Nijland J. (2015): "Doing Business in the Netherlands"

Brandts S., Laux C. (2007): "Cat bonds and reinsurance: the competitive effect of information-insensitive triggers"

Burnecki K., Kukla G., Taylor D. (2012): "Pricing of catastrophe bonds"

Canter M. S., Cole J.B. (1997) "The fundation and evolution of the catastrophe bond market"

Churney B. (2014): "AIR's 2014 Global Exceedance Probability Curve"

Cummins, J.D., Geman, H. (1995) "Pricing Catastrophe Insurance Futures and Call Spreads: An Arbitrage Approach "

Deloitte staff (2015): "Taxation and Investment in Netherlands 2015"

Edesess M. (2014): "Catastrophe Bonds: An Important New Financial Instrument"

Feinland Katz L. (2008): "Rating Agencies and Their Methodologies"

Giglio S. (2016): "Credit default swap spreads and systemic financial risk"

Gillen F., Beattie H., Farrell A., MacDonagh E., Parker R., Spratt T. (2013): "Choosing an SPV jurisdiction for a Structured Finance Transaction - Ireland: An Easy Choice "

Graaf F., de Vos F., Schreuder E., Hoozemans M., Dujardin F., Jacoby S., Kremer C., Mehlen M. (2011): “Choosing between a Dutch, an Irish and a Luxembourg SPV”

Grasso E., Vojkollari L., Falchero M., Picuti G. (2016): “The Italian Insurance Market”

Herdegen M. (2013): “Principles of International Economic Law”

Hull John C. (2008): “Options, Futures, and Other Derivatives”

International Network on the Financial Management of Large-Scale Catastrophes (2009): “Catastrophe-linked securities and capital markets”

Kolhatkar S. (2014): “The Legacy of JP Morgan's Blythe Masters”, Bloomberg Businessweek

Lalonde David A. and Karsenti P. (2008): “So you want to issue a Cat Bond”

Liu J., Xiao J., Yan L., Wen F. (2014): “Valuing Catastrophe Bonds Involving Credit Risks”

Marro E. (2016): “Cat bond, le “obbligazioni catastrofe”: otto domande e risposte per capire”, Il Sole 24 Ore

Modu E. , Irwin S. (2016): “Gauging the Basis Risk Of Catastrophe Bonds”

Nehushtan L., Mintz M., Kremer P., Zhuang R. (2016): “Insurance Linked Securities market update”

Nunn J., Humphreys M. (2014): “Insurance-Linked Securities “

Ogg J. (2016): “CDOs and the Mortgage Market”

Olivieri A., Pitacco E. (2015): “Introduction to Insurance Mathematics”

Paci S. (2016): “Assicurazioni: economia e gestione”

Patel N. (2015): “The Drivers of Catastrophe Bond Pricing”

Prestia G., Sullivan P. (1998): “Risk Securitization vs Traditional Reinsurance”

Puledda V. (2015): “Le assicurazioni portano in Italia la moda del bond anti-catastrofi”, la Repubblica

Richter A., MacMinn R. (2007): “The Choice of Trigger in an Insurance Linked Security”

Rodin J. (2015): “Innovative Finance Has a Major Role to Play in Tackling Climate Change”

Rosso R. (2016): “Catastrofi naturali, pro e contro dei Cat Bond”, Il Fatto Quotidiano

Simic M. (2011): “Cat Modelling Update from AIR”

Scowcroft John A., Guadagnuolo L., Puccia M. (2015): “What Are Rating Criteria?”

Shaffer R., Agusti F., Dhooge L, Earle B. (2012): “International Business Law and Its Environment”

Shumway M. (2009): “Rating Agency Methodology and Practice in Asia-Pacific”

Steffens P. (2014): “Dutch SPVs in European CLO Transactions”

Tavakoli Janet M. (2001): “Credit Derivatives & Synthetic Structures: A Guide to Instruments and Applications”

Taylor S. (2005): “Asset Price Dynamics, Volatility and Prediction”

Teather D. (2018): “The woman who built financial 'weapon of mass destruction'”, The Guardian

Vacarini F., Parboni M., Vantaggi G., Donati A. (2016): “Unipol: social innovation, value creation and reliability are the business principles of the future”

van Deventer Donald R. (2011): “Credit Derivatives and Hedging Credit Risk”

Voegele W. (2013): “Business Luxembourg Company Formation”

Wong C. (2016): “Understanding Catastrophe Bonds from an Investor’s Perspective”

Zabel Richard R. (2008): “Credit Default Swaps: From Protection To Speculation”

Sitography

AIR Worldwide Corporation, www.air-worldwide.com

Alvarez A. (2014): “A brief history of cat bond prices – part one”, https://insurancelinked.com/brief-history-cat-bond-prices-part-one/

ANIA, www.ania.it

ANIA, “Italian Insurance in Figures”, www.ania.it/export/sites/default/it/pubblicazioni/rapporti-annuali/Italian-Insurance-In-Figures/2016/Ass-in-cifre-2016-ingl-web.pdf

Artemis, “Average catastrophe bond & ILS issuance expected loss and coupon by year”, www.artemis.bm/deal_directory/cat_bonds_ils_expected_loss_coupon.html

Artemis, “Azzurro Re I Limited - Full details”, www.artemis.bm/deal_directory/azzurro-re-i-limited/

Artemis, “Catastrophe bonds & ILS issued and outstanding by year”, www.artemis.bm/deal_directory/cat_bonds_ils_issued_outstanding.html

Artemis, “Catastrophe bonds & ILS outstanding by coupon pricing”, www.artemis.bm/deal_directory/cat_bonds_ils_by_coupon_pricing.html

Artemis, “Catastrophe bonds & ILS outstanding by trigger type”, www.artemis.bm/deal_directory/cat_bonds_ils_by_trigger.html

Artemis, “Cat bond funds don’t expect Harvey loss, private ILS more exposed”, www.artemis.bm/blog/2017/08/29/cat-bond-funds-dont-expect-harvey-loss-private-ils-more-exposed/

Artemis, “Cat bond market averages 8.33% annual growth since 2002: Swiss Re”, www.artemis.bm/blog/2015/01/29/cat-bond-market-averages-8-33-annual-growth-since-2002-swiss-re/

Artemis, “First time sponsors discuss catastrophe bond pros and cons”, www.artemis.bm/blog/2014/09/16/first-time-sponsors-discuss-catastrophe-bond-pros-and-cons/

Artemis, “Harvey won’t cause cat bond loss but could erode aggregates: Paul Schultz”, www.artemis.bm/blog/2017/08/30/harvey-wont-cause-cat-bond-loss-but-could-erode-aggregates-paul-schultz/

Artemis, “Is ‘basis risk’ the right question when considering parametric triggers?”, www.artemis.bm/blog/2015/11/19/is-basis-risk-the-right-question-when-considering-parametric-triggers/

Artemis, “Latest catastrophe bonds and insurance-linked securities”, www.artemis.bm/deal_directory/

Artemis, "Lion I Re DAC - Full details”, www.artemis.bm/deal_directory/lion-i-re-ltd/

Artemis, “Lion II Re cat bond from Generali set new pricing multiple low: GC Securities”, www.artemis.bm/blog/2017/07/12/lion-ii-re-cat-bond-from-generali-set-new-pricing-multiple-low-gc-securities/

Artemis, "Lion II Re DAC - Full details”, www.artemis.bm/deal_directory/lion-ii-re-dac/

Artemis, “What is a catastrophe bond (or cat bond)?”, www.artemis.bm/library/what-is-a-catastrophe-bond.html

Bishop A. (2011): “Insurance indemnity limits, types and usage examples”, http://riskheads.org/insurance-indemnity-limits-types-examples/

Bloomberg, www.bloomberg.com

Bullard N. (2017): “Blockchains Get Into the Catastrophe Business”, Bloomberg, https://www.bloomberg.com/view/articles/2017-08-11/blockchains-get-into-the-catastrophe-business

Clifford Chance, www.cliffordchance.com

CRESTA, www.cresta.org

Euribor, “Tassi storici Euribor”, www.euribor.it/tassi-storici-euribor/

Fitch Ratings, www.fitchratings.com

Generali Assicurazioni S.p.A., www.generali.com

Ghetu D. (2011): “AIR Worldwide European Wind and Earthquake Cat Models offer a broader and unified view of risk across Europe", www.xprimm.com/AIR-Worldwide-European-Wind-and-Earthquake-Cat-Models-offer-a-broader-and-unified-view-of-risk-across-Europe-articol-117,124-797.htm

Hainey R. (2017): "Catastrophe bonds hit record levels", www.royalgazette.com/re-insurance/article/20170104/catastrophe-bonds-hit-record-levels

Insurance Europe, "Insurance Europe Statistics N°50: European Insurance in Figures, December 2014", www.insuranceeurope.eu/sites/default/files/attachments/StatisticsNo50EuropeanInsuranceinFigures.pdf

International Overseas Services, "Netherlands - Beslooten Venootschaap (BV), http://ioserv.com/en/jurisdictions/onshore/netherlands_bv/

Italian National Seismic Network, www.fdsn.org/networks/detail/IV/

IVASS, www.ivass.it

Laudermilk B. (2011): "Catastrophe Bonds: What they are, their risk, their benefits, and how to protect yourself", http://chinainvestin.com/index.php/en/china-offshore/reports/1502

Luxembourg Consulting Group, www.lcg-luxembourg.com

PERILS: losses, www.perils.org/losses

Reuters staff (2015): "Fitch Rates Azzurro Re I Ltd. Catastrophe Bond Class A Notes 'BB+sf'; Outlook Stable", www.reuters.com/article/idUSFit92628820150618

Reuters Staff (2015): "Fitch Rates Azzurro Re I Ltd. Catastrophe Bond Class A Notes 'BB+sf'; Outlook Stable", www.reuters.com/article/idUSFit92628820150618

Revenue – Irish Tax and Customs, www.revenue.ie

RMS, www.rms.com

RQE, "RQE CAT Modeling Platform", www.corelogic.com/products/rqe.aspx

Schroders, “Insurance-Linked Securities”, www.schroders.co.uk/globalassets/schroders/sites/pensions/pdfs/schroders-insurance-linked-securities-brochure-may-2014.pdf

Standard & Poor’s Ratings, www.spratings.com

Statista, “Leading five non-life insurance companies in Italy in 2015, by market share of gross written premiums”, www.statista.com/statistics/474984/top-non-life-insurance-companies-by-gross-written-premiums-market-share-in-italy/

Tax Consultants International, “Corporation or Branch?”, www.tax-consultants-international.com/read/Corporation_branch_netherlands?submenu=3626&sublist=3274

Tax Consultants International, “Dutch accounting and audit requirements”, www.tax-consultants-international.com/read/accounting_audit_netherlands

Tax Consultants International, “How to incorporate a BV in the Netherlands”, www.tax-consultants-international.com/read/How_to_incorporate_a_BV#4

UnipolSai Assicurazioni S.p.A., www.unipolsai.it

UnipolSai Assicurazioni S.p.A., “Market capitalization”, www.unipolsai.com/en/Investor-Relations/share-information/Pages/Market-Capitalization.aspx

Withers O., Shah J. (2015): “Cat Bond Pricing: Calculating the True Rewards”, www.rms.com/blog/2015/11/05/cat-bond-pricing-calculating-the-true-rewards/

Acknowledgments

This work settles the end of this five-year journey with the achievement of an important goal. It has been sometimes difficult, but yet fun and always formative at the same time.

A first, big, lovely thank goes to my entire family, especially to my parents and my brother, who have always believed in me and supported me in the joys and in the difficulties of this experience. A special thank also to all my beloved grandparents, hoping that, here or up there, all of them are seeing in me now the person they wanted me to become.

For sure a heartfelt acknowledgment needs to be done in particular to Ilaria for her continuous support, and to all my chosen brothers, my best friends, for always having been there when I needed them.

I would like to sincerely thank Professor Corazza, my academic advisor, for having always and patiently helped and supported me during these months, and for his very precious advices.

A sincere acknowledgment goes also to Mr Sordoni for his kindness and his great disposability.

Finally, thanks also to my all companions whom I shared this journey with.